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Virr

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(54) **REMOVABLE AND/OR REPLACEABLE HUMIDIFIER**

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(Continued)

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
A61M 16/10 (2006.01)
A61M 16/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61M 16/142*** (2014.02); ***A61M 16/022*** (2017.08); ***A61M 16/109*** (2014.02);
(Continued)

(58) **Field of Classification Search**
CPC A61M 16/1075; A61M 16/109; A61M 16/142; A61M 16/16; A61M 16/202;
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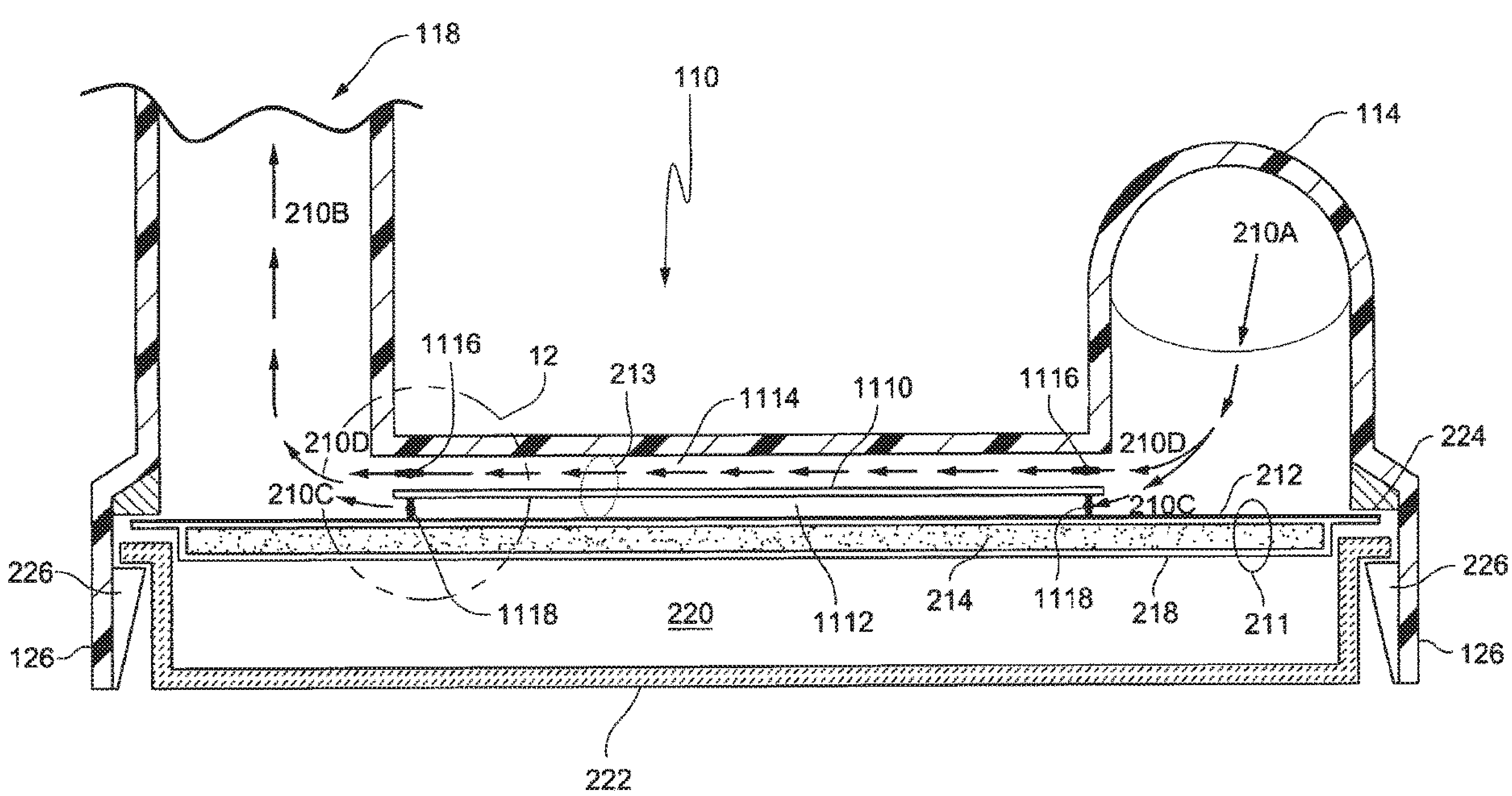
(57) **ABSTRACT**

Humidifier apparatus for a respiratory apparatus includes a housing providing a gas flow path, a heater apparatus, and a water supply distribution member configured and arranged to deliver water vapour to the gas flow path. The water distribution member is provided to the housing and in thermal communication with the heater apparatus.

13 Claims, 19 Drawing Sheets



Related U.S. Application Data

continuation of application No. 12/213,958, filed on Jun. 26, 2008, now Pat. No. 8,550,075.

(51) **Int. Cl.**

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A61M 16/14	(2006.01)
A61M 16/20	(2006.01)
A61M 16/00	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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See application file for complete search history.

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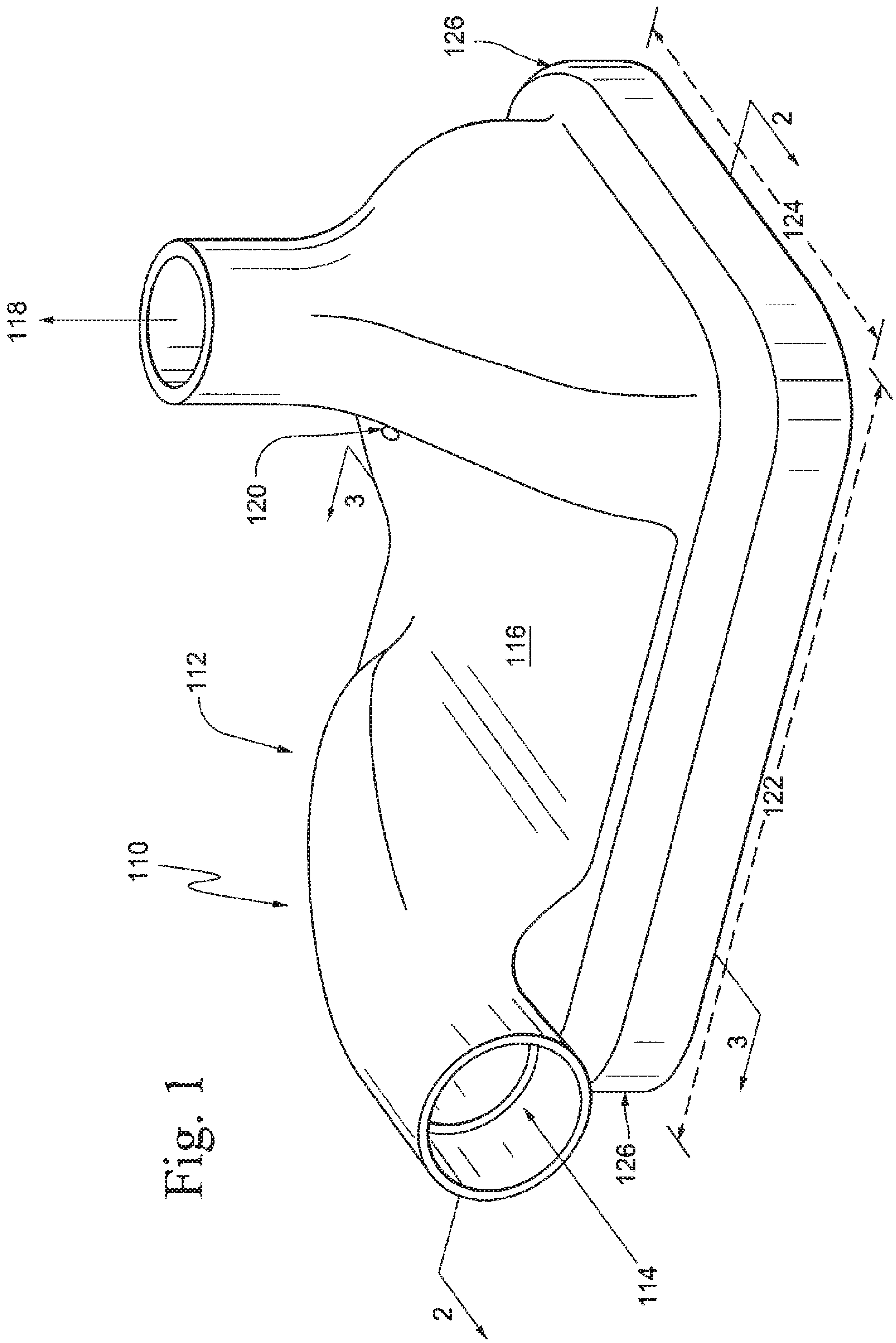

Fig. 1

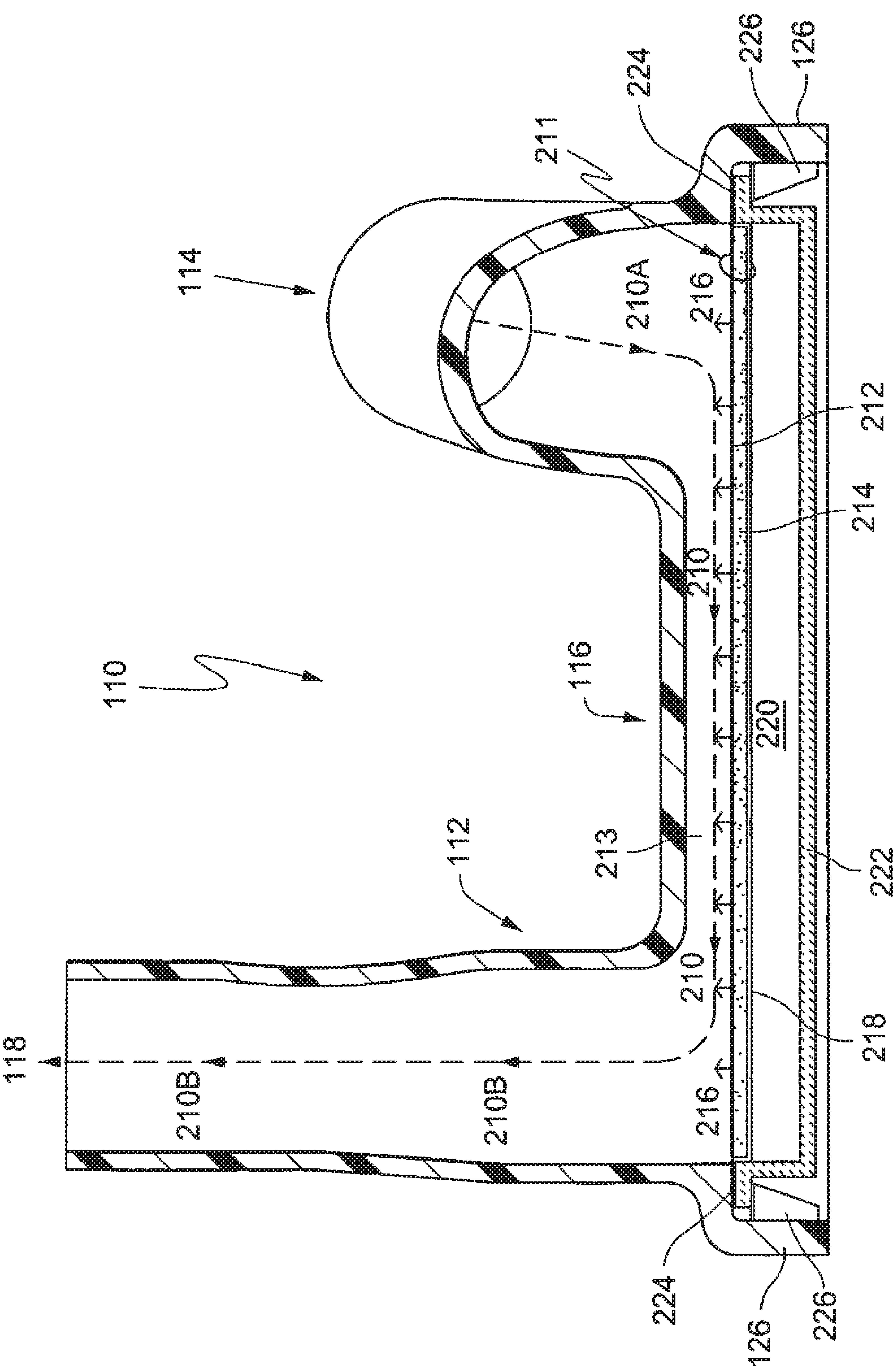
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Fig. 2

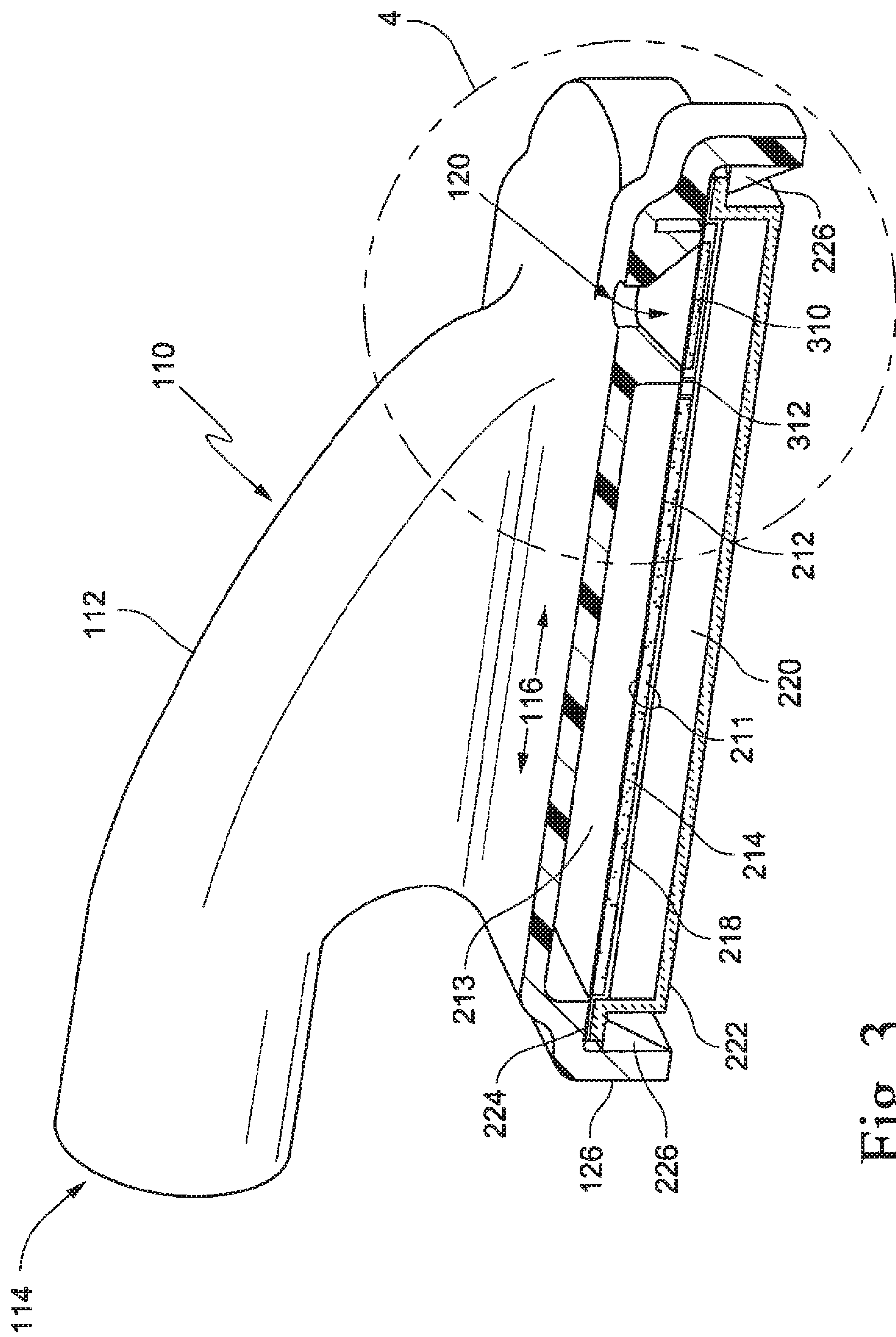
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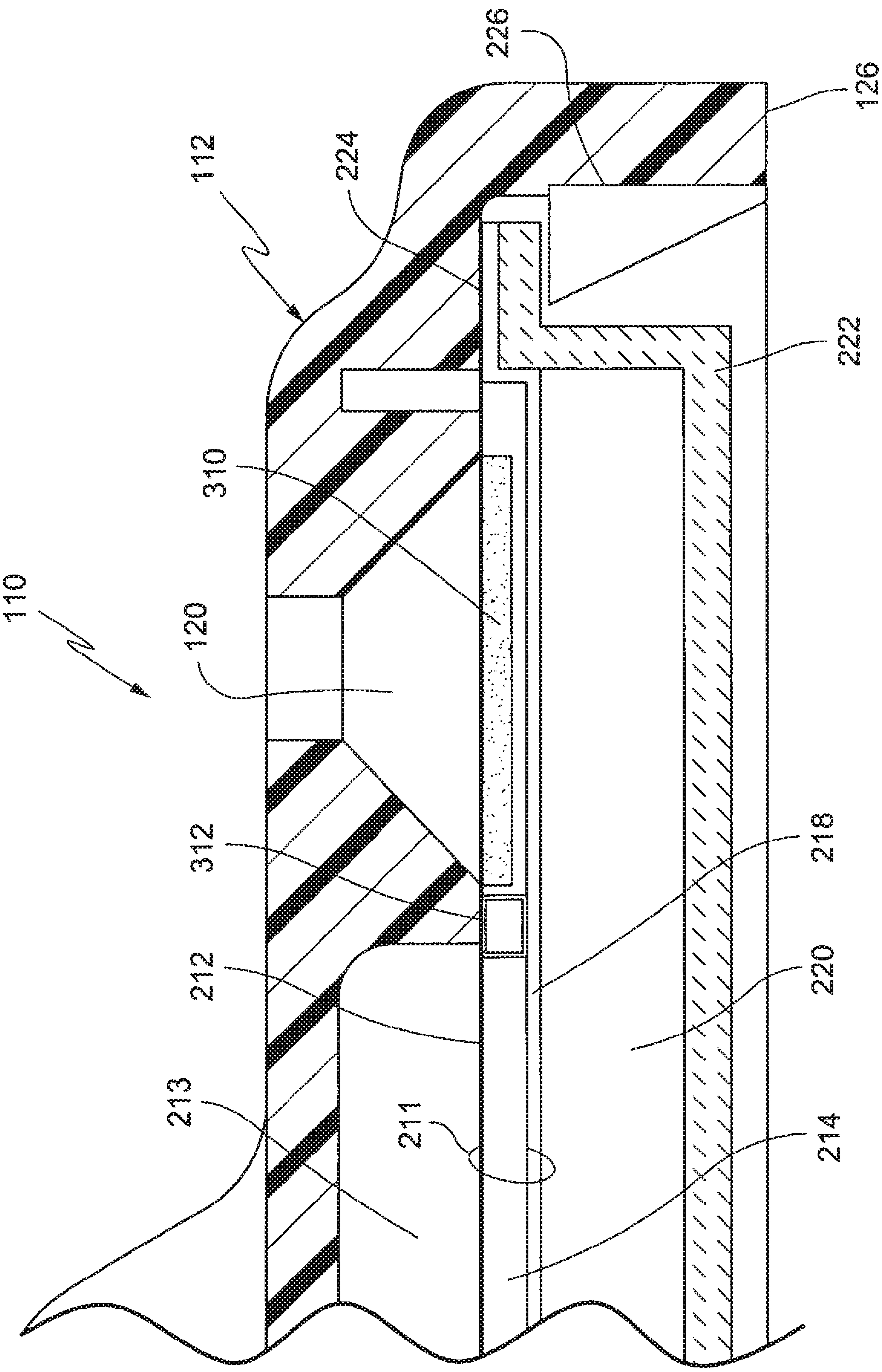
Fig. 3



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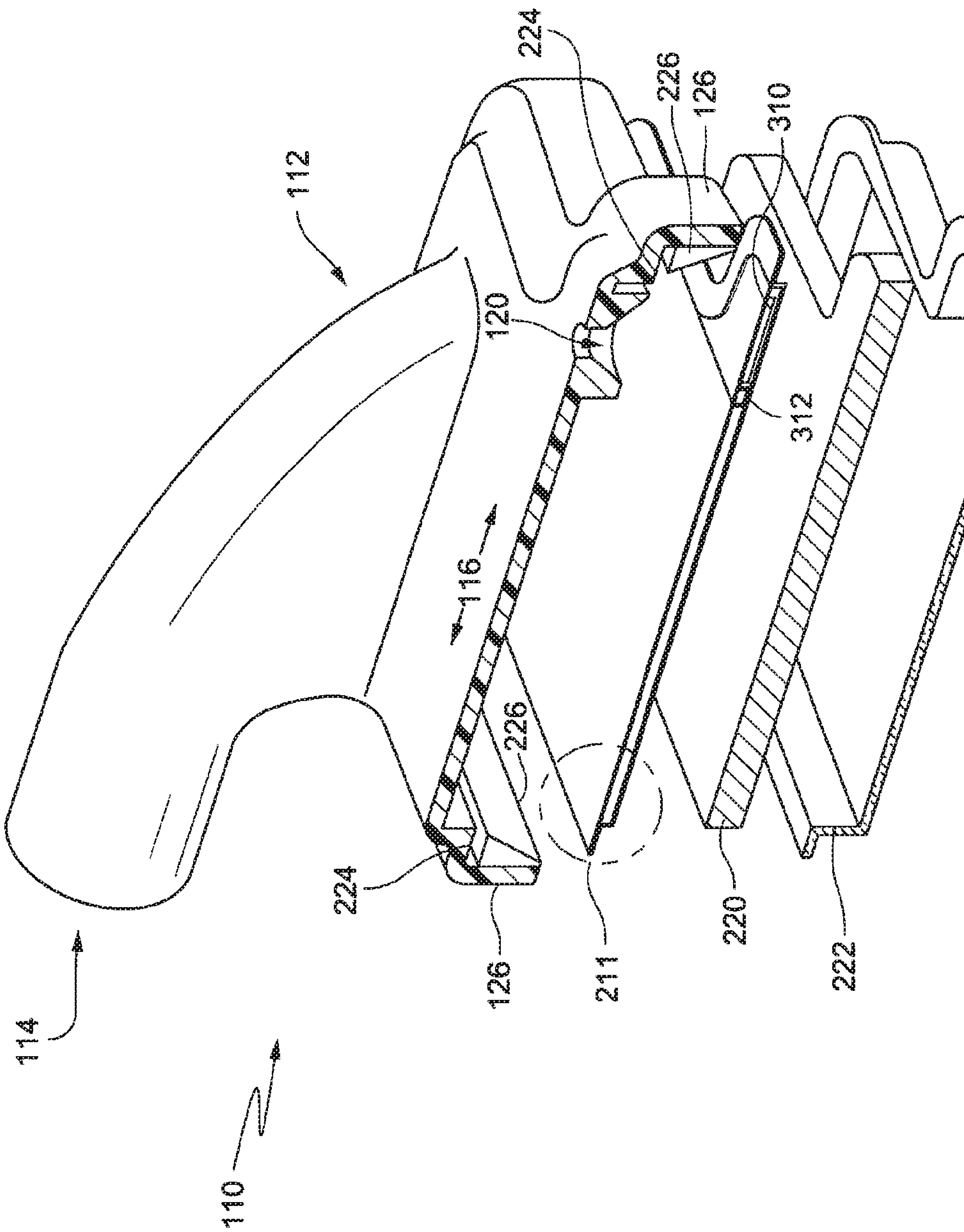

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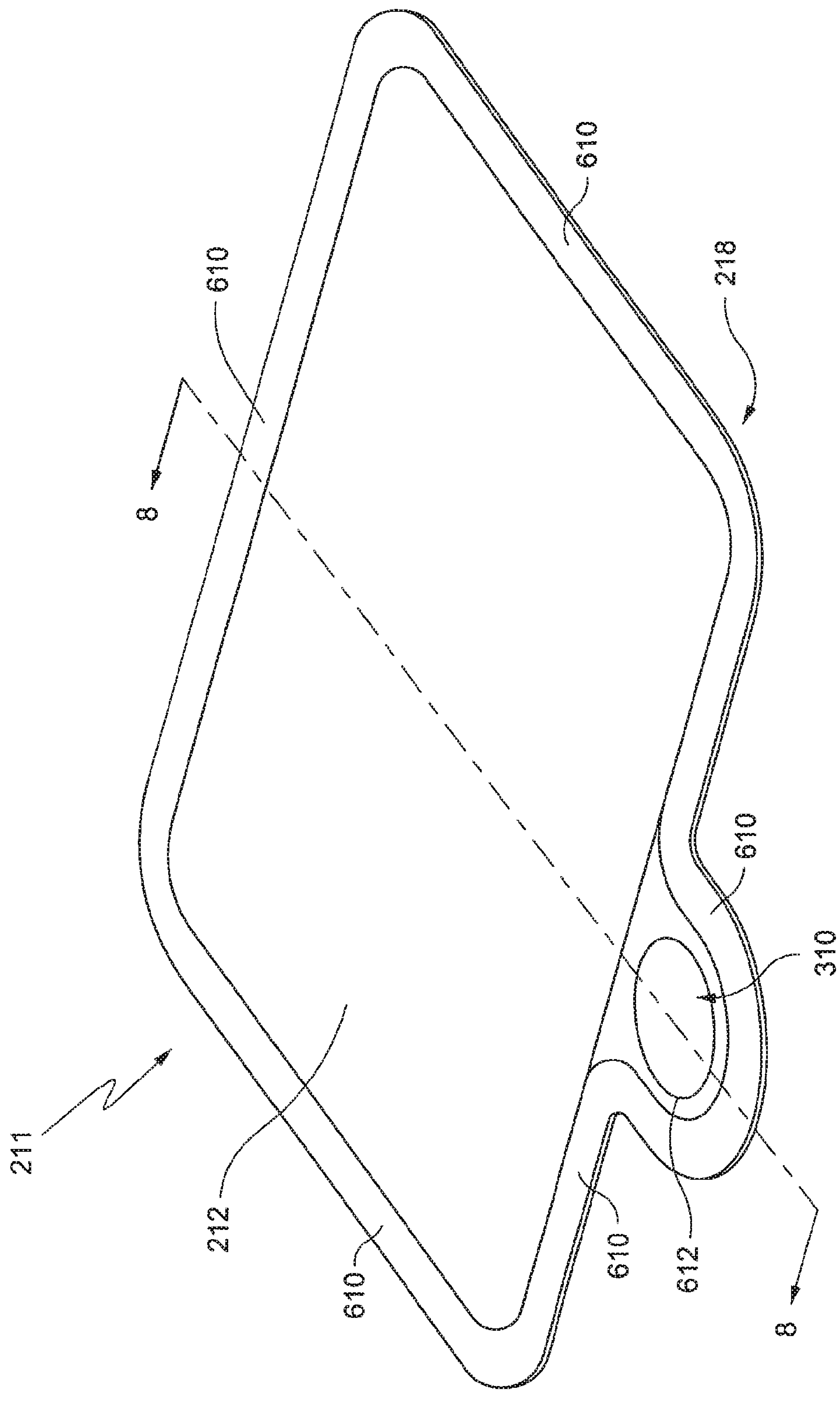

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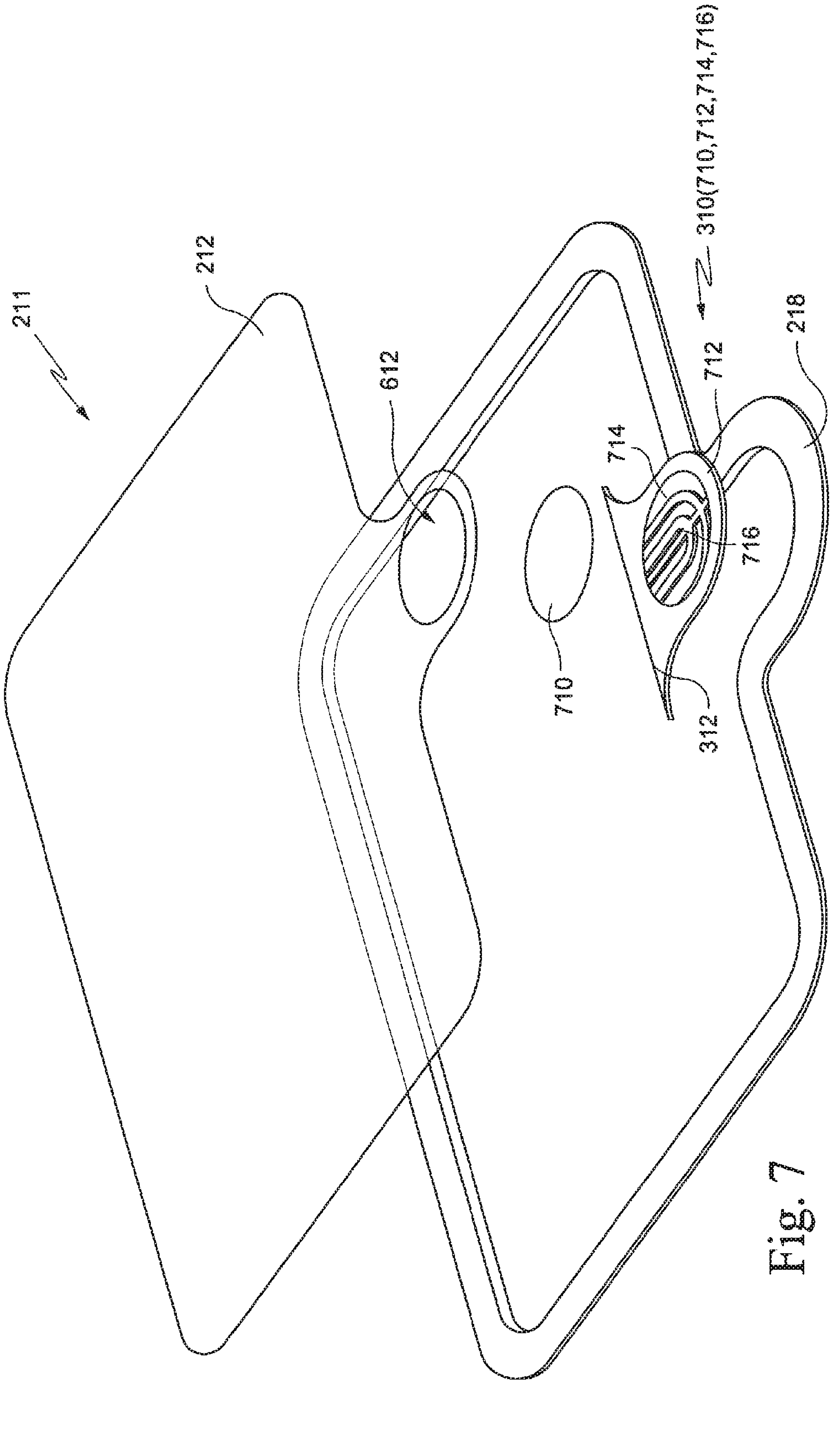

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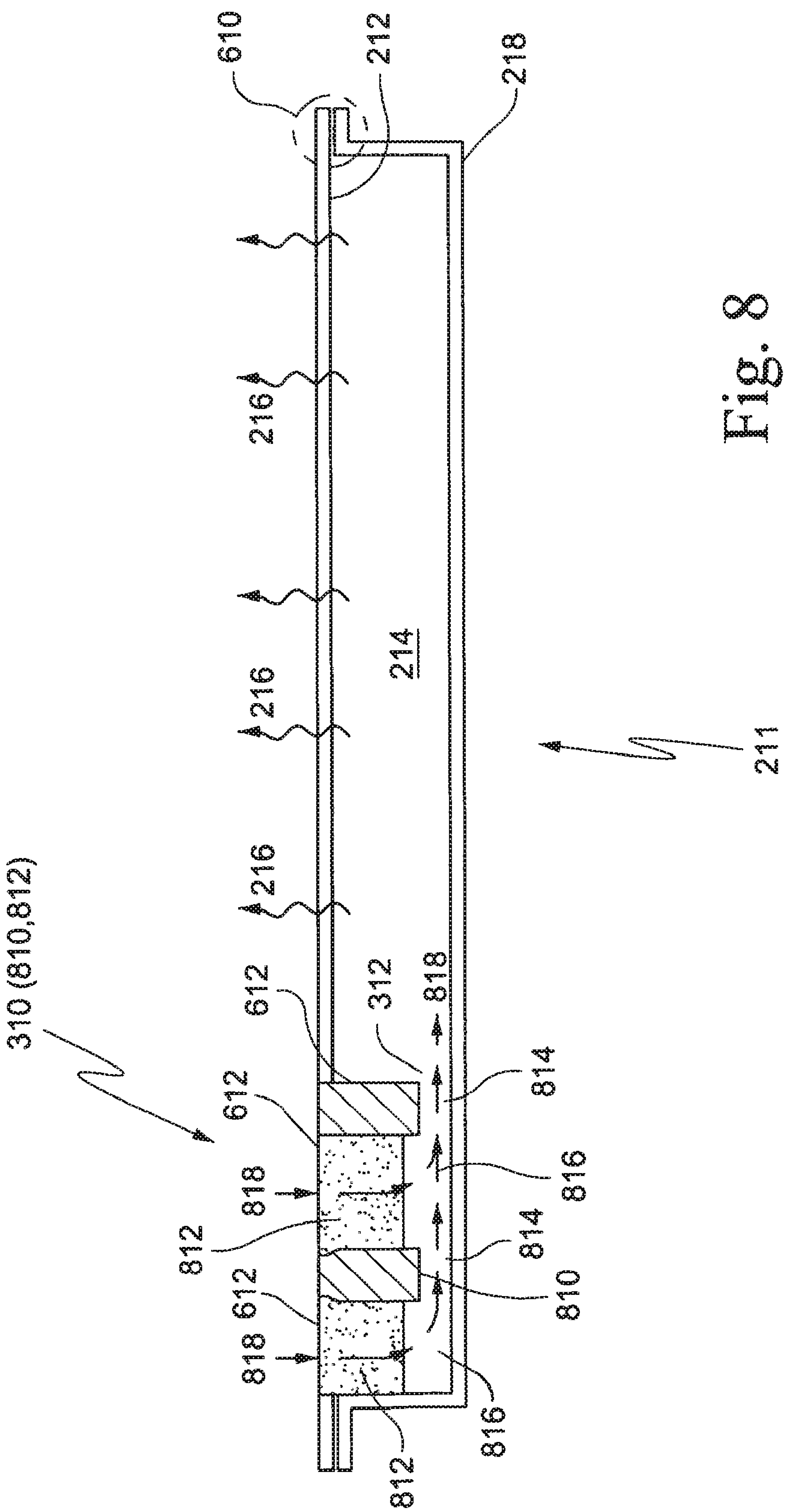
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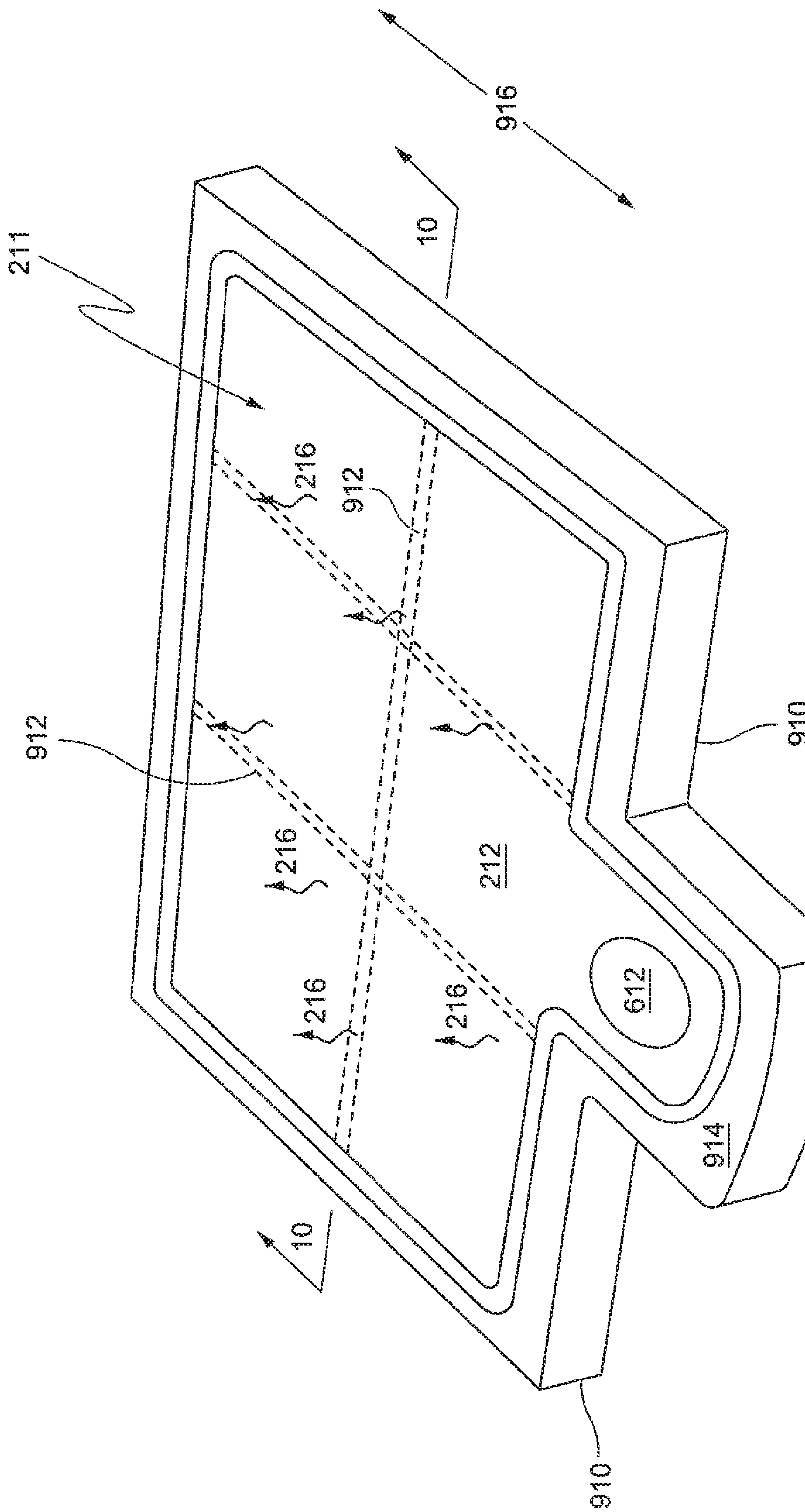
Fig. 8



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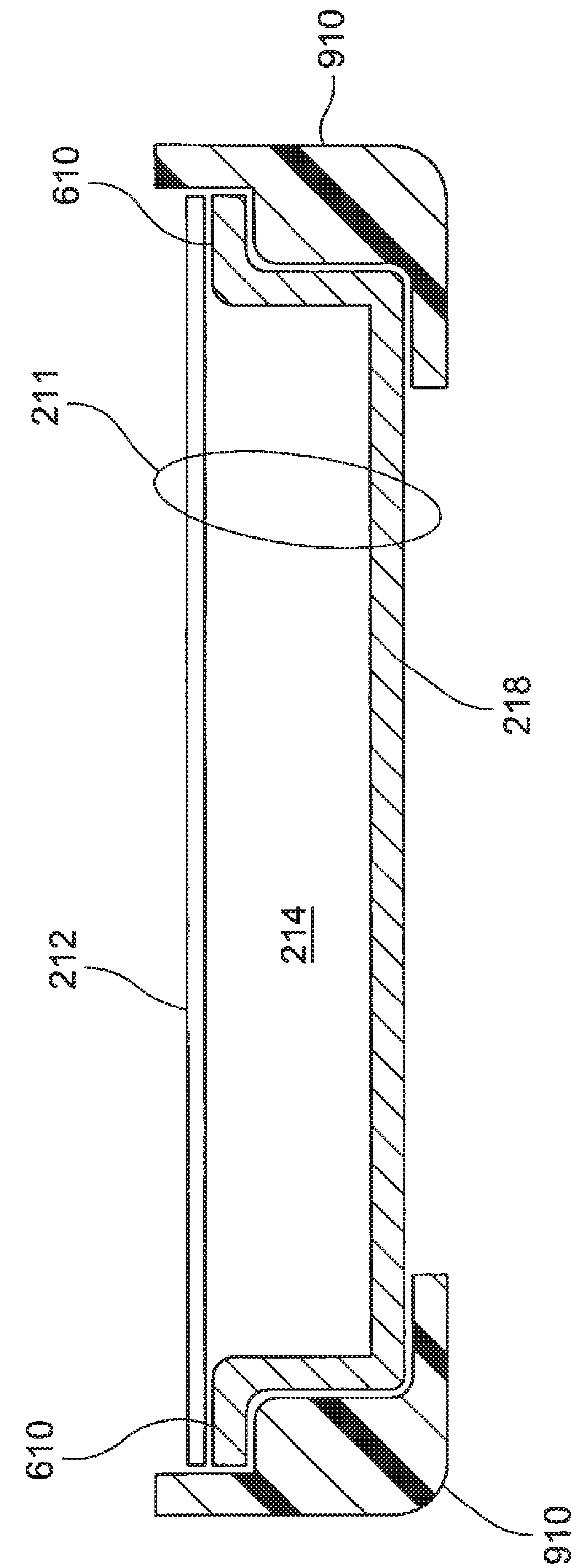

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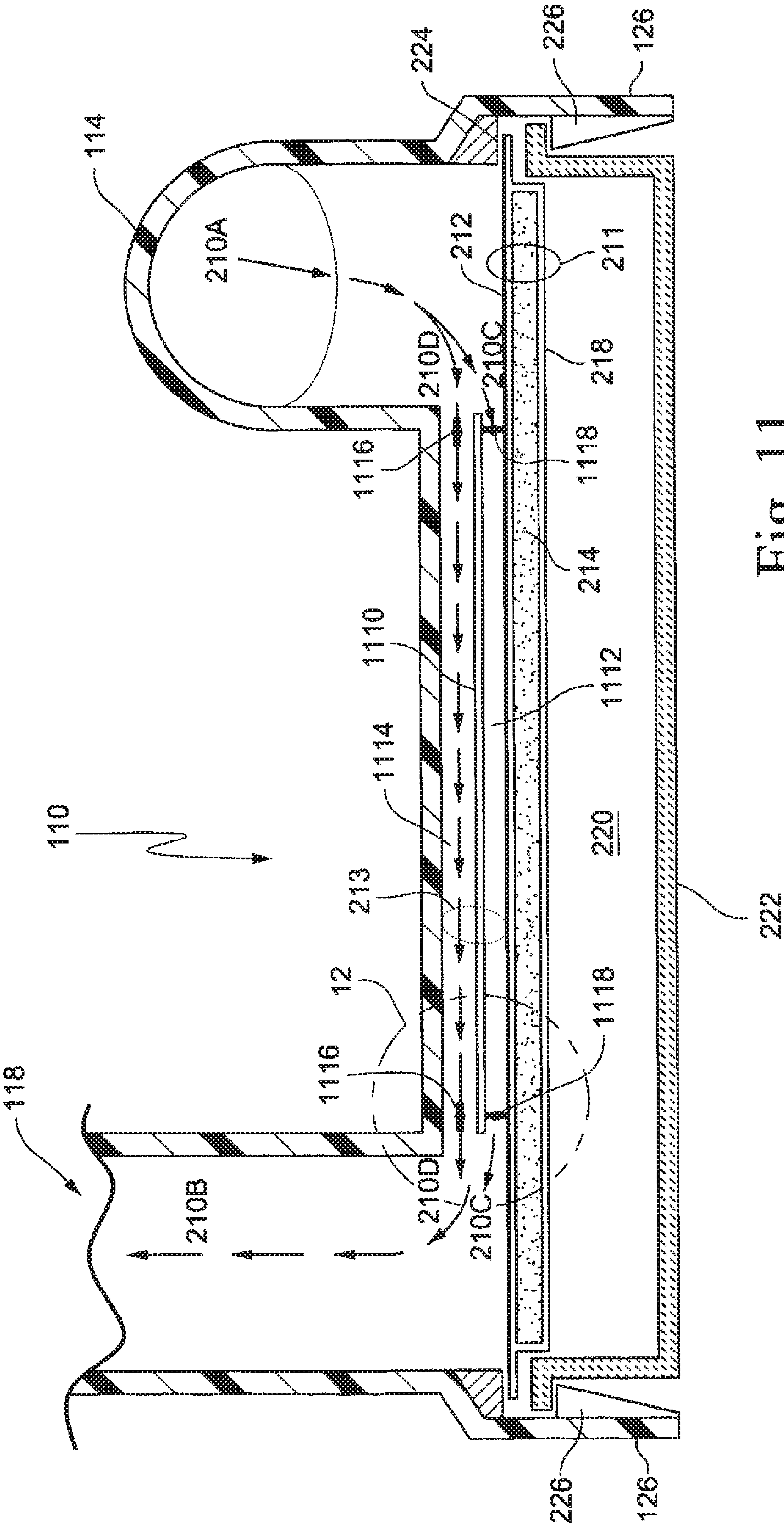
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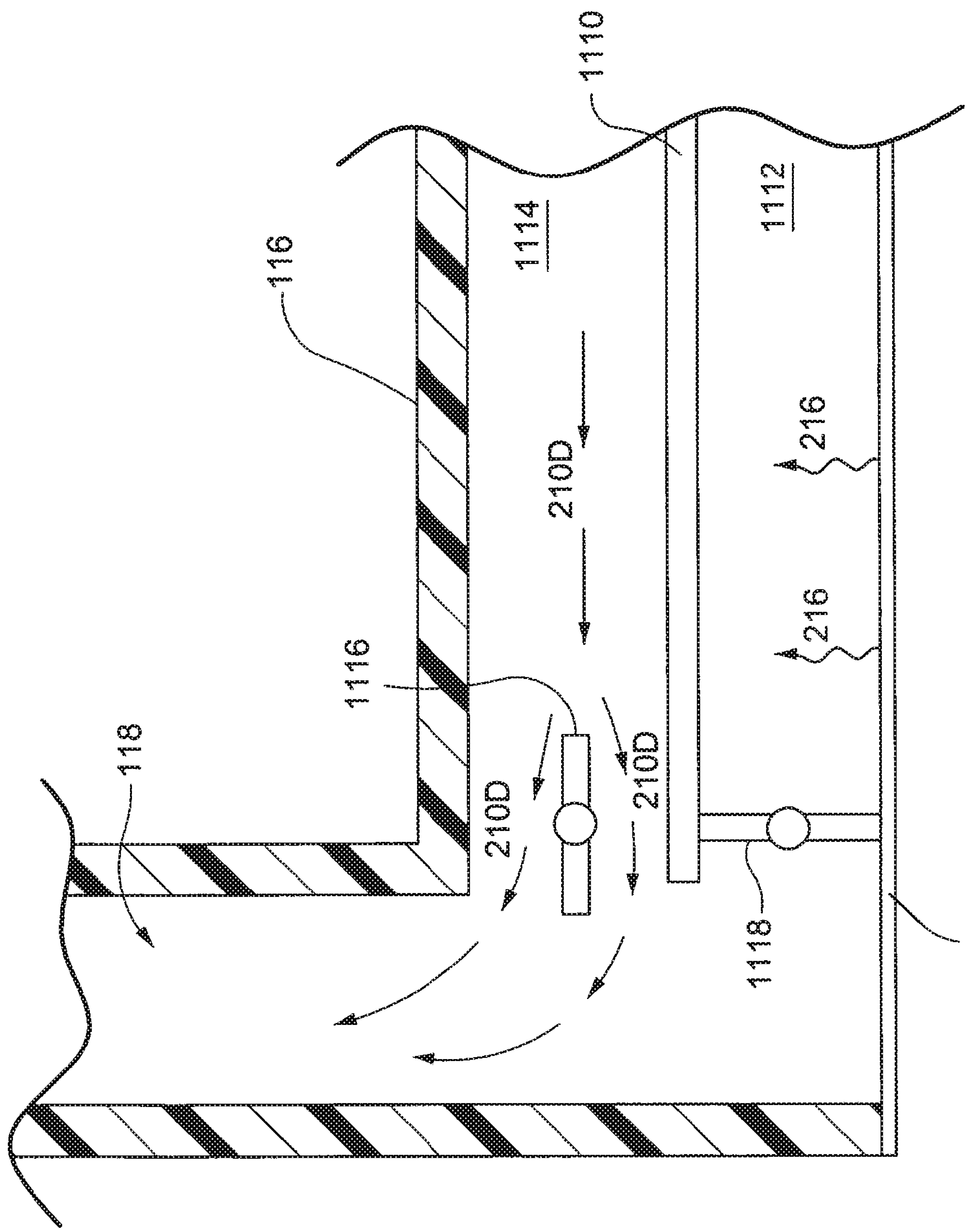
Fig. 11

Fig. 12



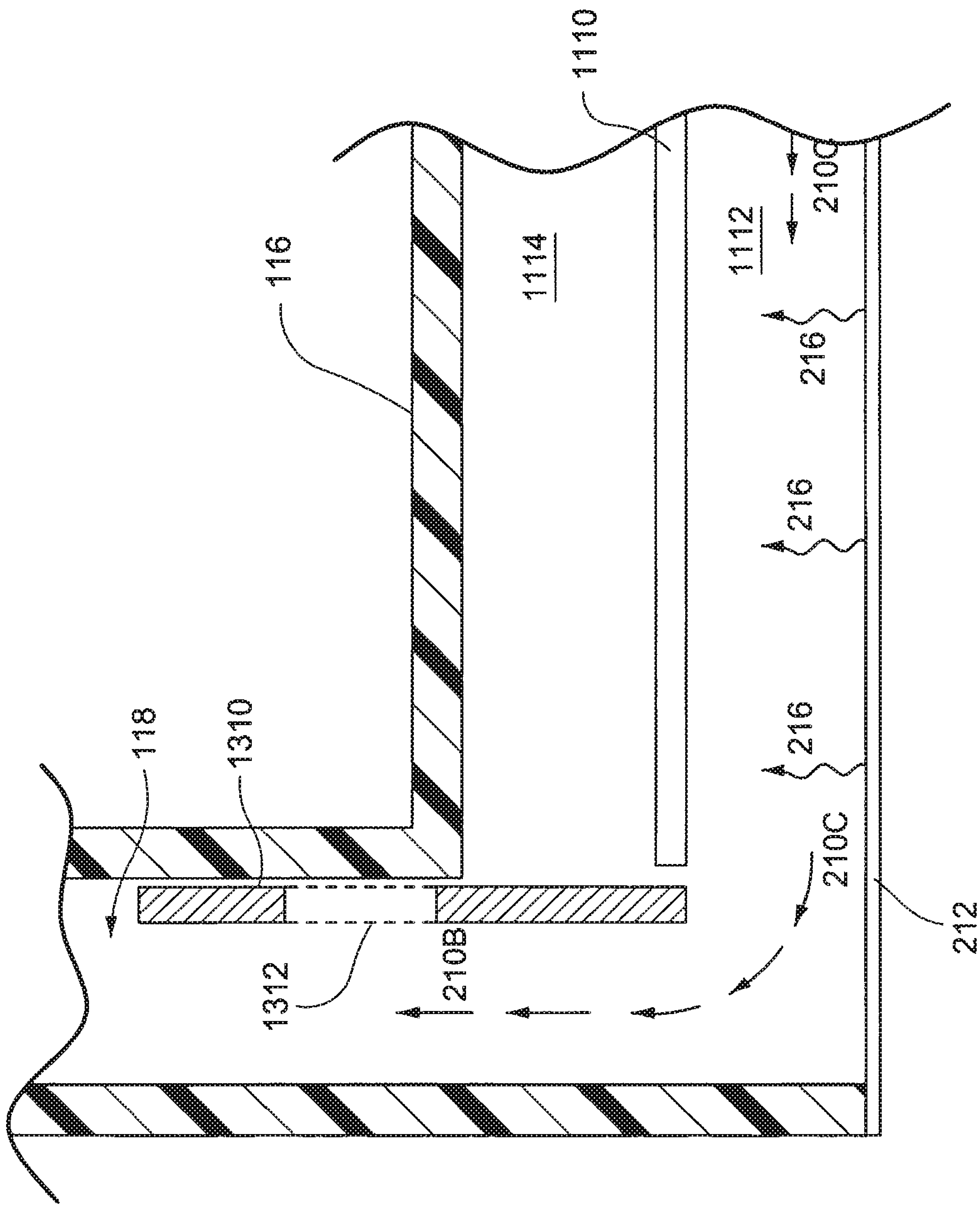

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Fig. 13

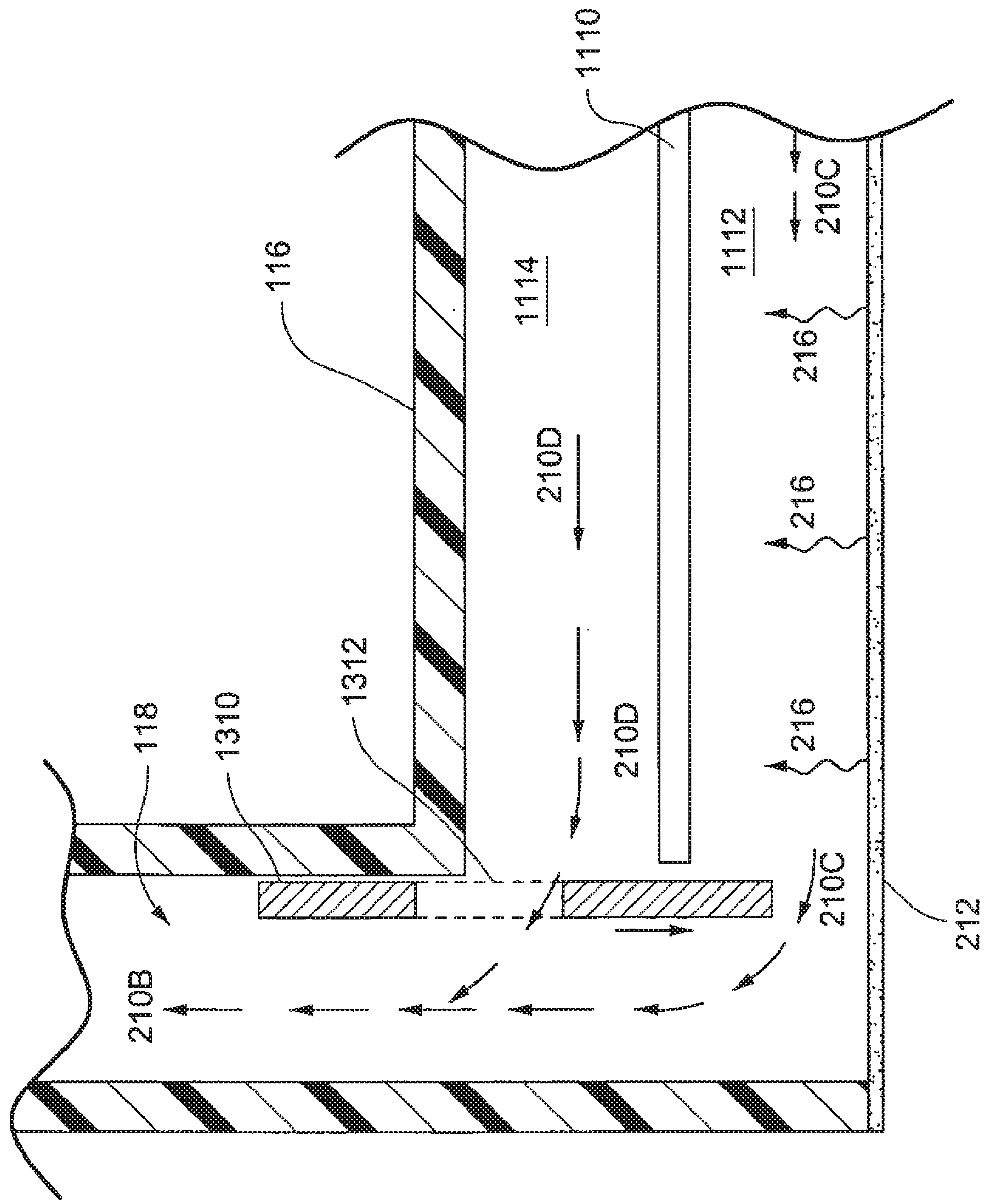
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Fig. 14

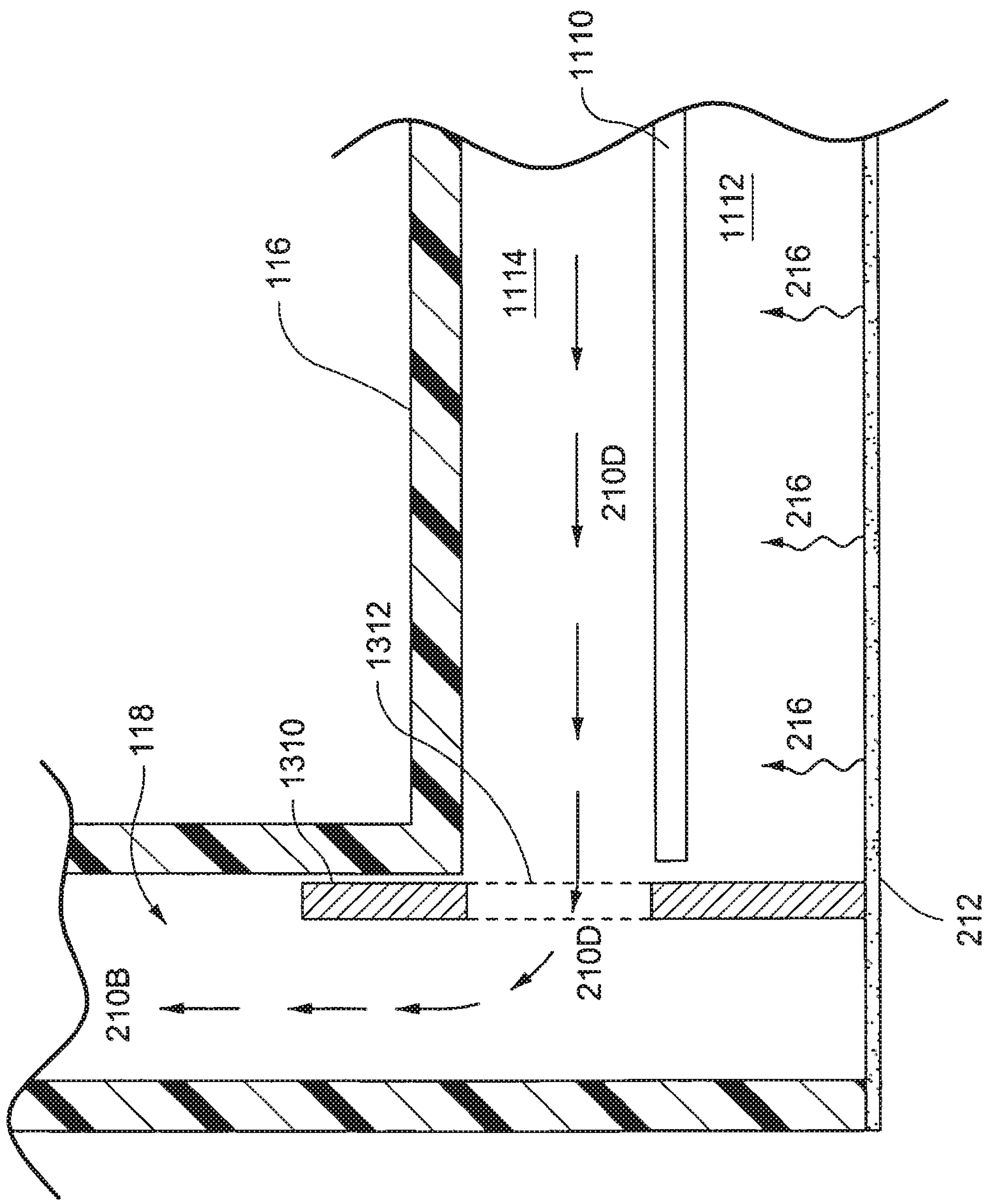
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Fig. 15

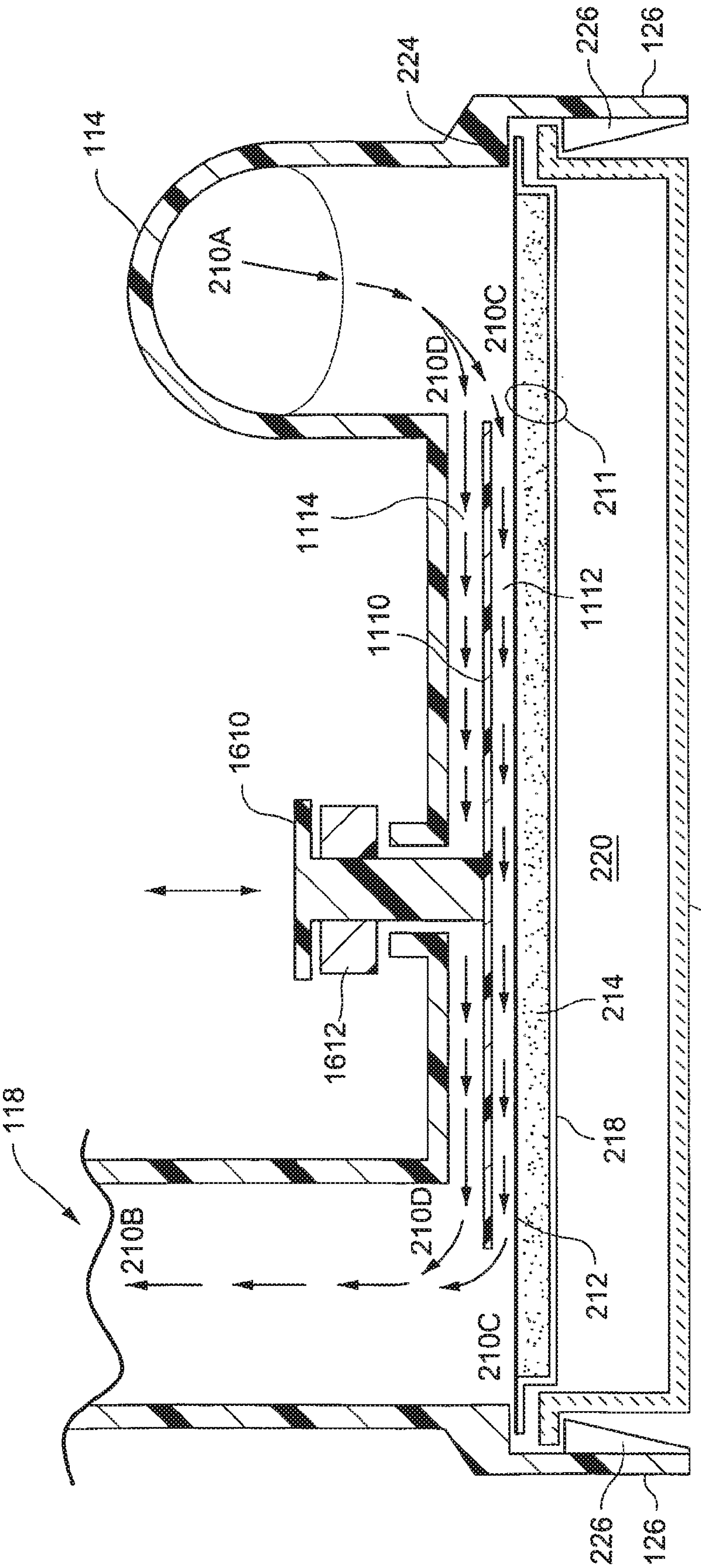
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Fig. 16

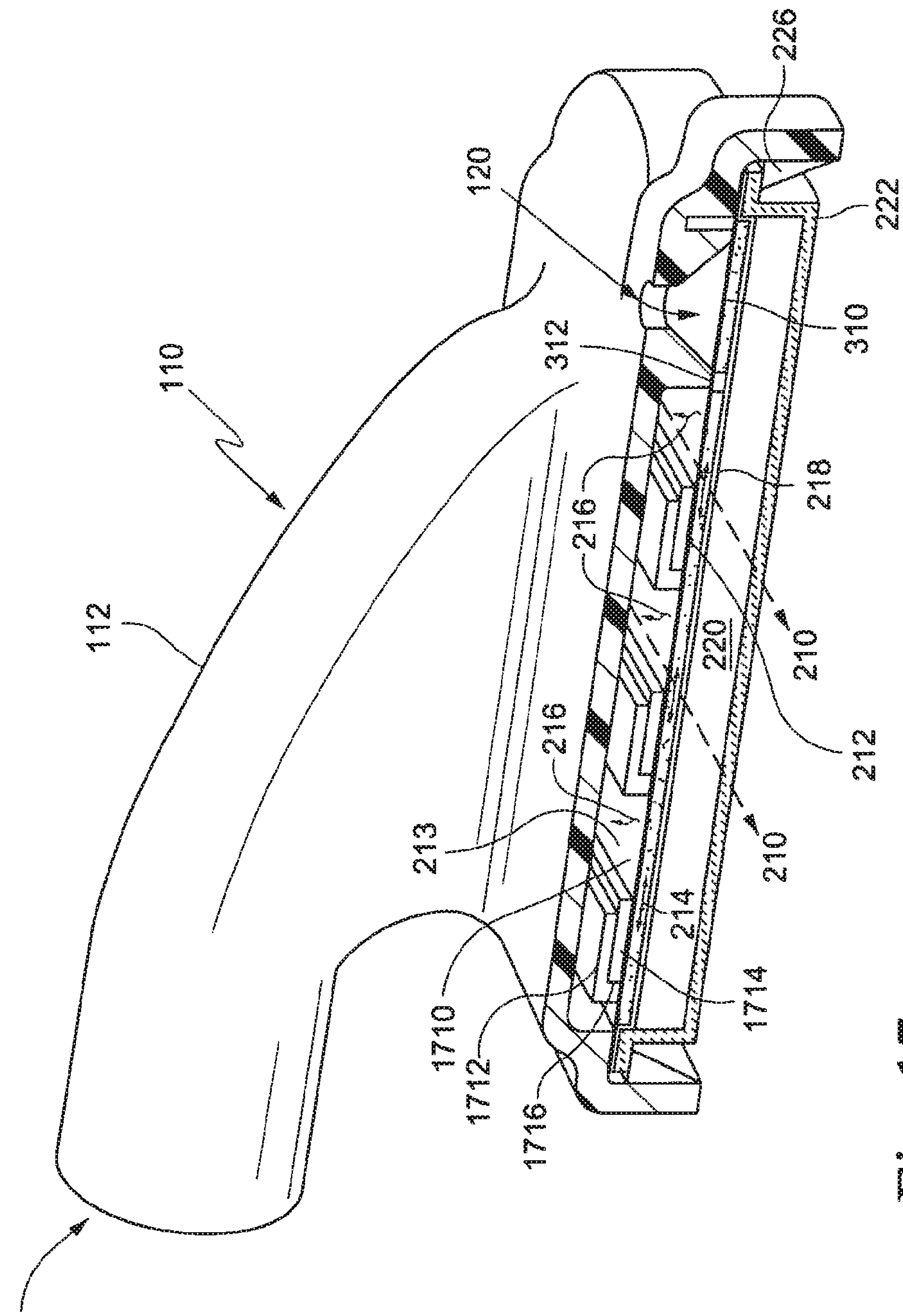
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Fig. 17

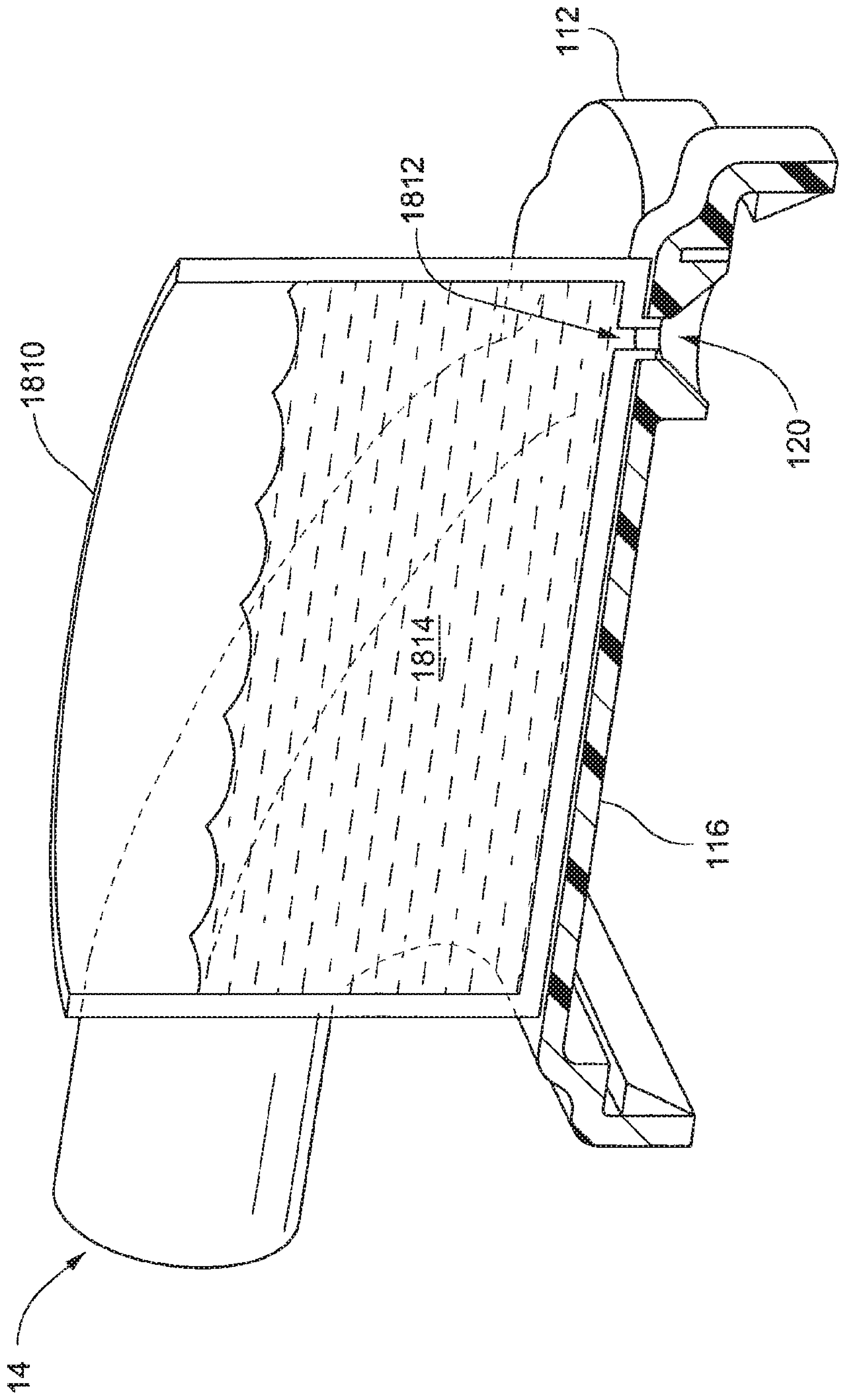

Fig. 18

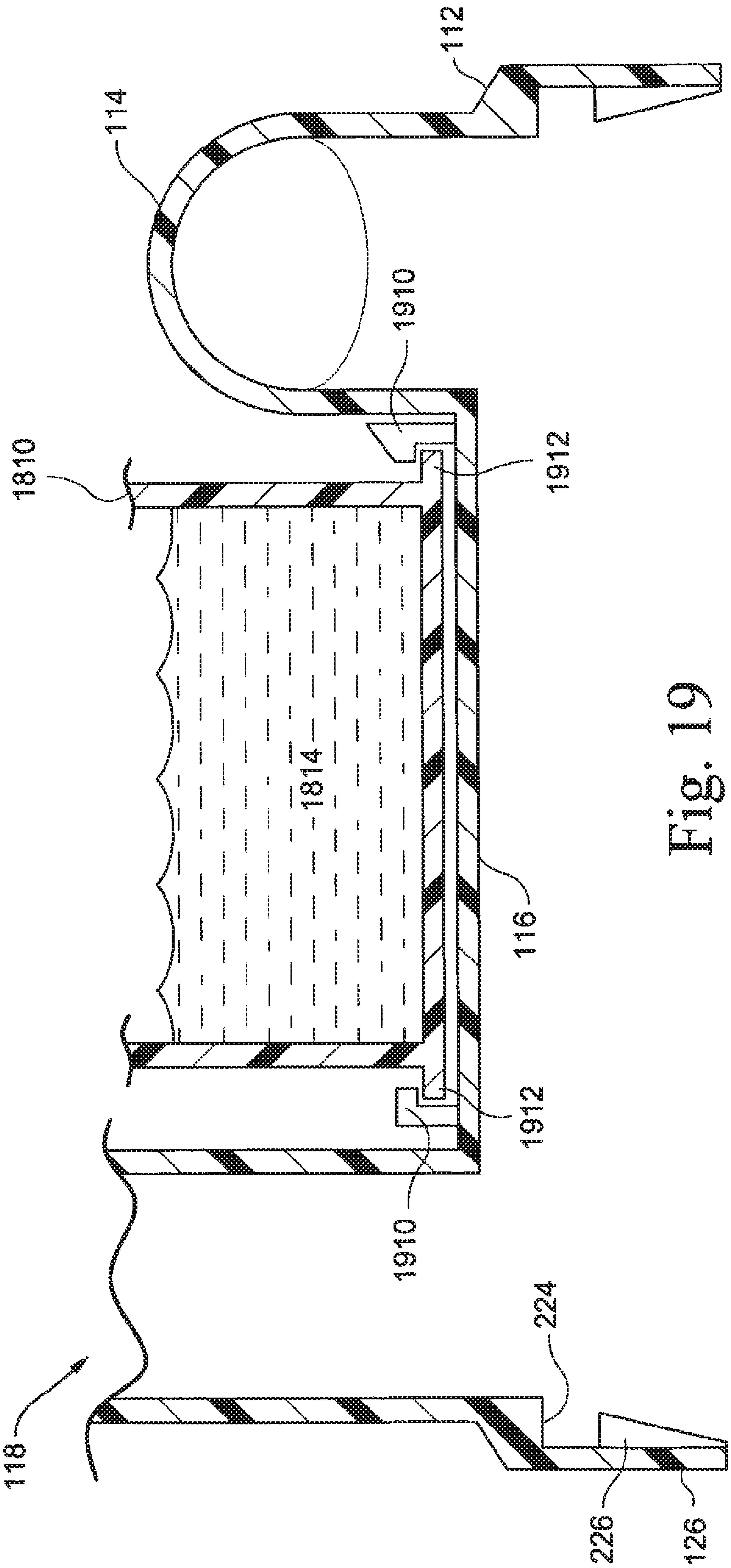

Fig. 19

REMOVABLE AND/OR REPLACEABLE HUMIDIFIER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/016,797, filed Sep. 3, 2013, now allowed, which is a continuation of U.S. patent application Ser. No. 12/213,958, filed Jun. 26, 2008, now U.S. Pat. No. 8,550, 075, which claims priority to Australian Application No. AU 2007903508, filed Jun. 28, 2007, the entire contents of each which is incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to humidification arrangements used to control the humidity of breathable gases used in respiratory apparatus ventilation systems including invasive and non-invasive ventilation, Continuous Positive Airway Pressure (CPAP), Bi-level therapy and treatment for sleep disordered breathing (SDB) conditions such as Obstructive Sleep Apnea (OSA), and for various other respiratory disorders and diseases.

2. Description of the Art

Respiratory apparatus commonly have devices to alter the humidity of the breathable gas in order to reduce drying of the patient's airway and consequent patient discomfort and associated complications. The use of a humidifier placed between the positive airway pressure device (or flow generator) and the patient mask produces humidified gas that minimizes drying of the nasal mucosa and increases patient airway comfort.

Many humidifier types have been proposed, including humidifiers that are either integrated with or configured to be coupled to the relevant respiratory apparatus. While passive humidifiers can provide some relief, generally a heated humidifier is required to provide sufficient humidity and temperature to the air so that patient will be comfortable.

Humidifiers typically comprise a water tub having a capacity of several hundred milliliters, a heating element for heating the water in the tub, a control to enable the level of humidification to be varied, a gas inlet to receive gas from the positive airway pressure device, and a gas outlet adapted to be connected to a gas conduit that delivers the humidified pressurized gas to the patient's mask.

Tub-of-water humidifiers are vulnerable to liquid water spillage if they are not maintained in a substantially vertical orientation. Spillage of liquid water can either travel into the gas conduit to the patient or back into the positive airway pressure device and associated electronics or deplete the reservoir of humidifying water. In either of the cases, the spillage of water is undesirable.

A semi-permeable membrane may be used to isolate the liquid water from the gas flow. The semi-permeable membrane has the characteristic of allowing water vapour to pass through it but not liquid water. Water vapour passing through the semi-permeable membrane may be entrained into the gas flow within the humidifier and then passed to the patient.

U.S. Pat. Nos. 3,871,373, 4,146,597 and 4,155,961 disclose the use of tubes of semi-permeable membrane, containing liquid water, inserted into the gas flow path. The tubes are used as a source of water vapour for entraining into the passing gas flow stream.

U.S. Pat. Nos. 4,753,758 and 4,921,642 disclose the use of a semi-permeable membrane to separate a water chamber and a gas flow path chamber of a humidifier. In these examples, the water and gas flow chambers are typically generous in their volumes with consequently a high thermal capacity and slow thermal response.

U.S. Pat. Nos. 4,910,384 and 5,062,145 disclose a heater situated within a water-containing envelope of semi-permeable membrane material, dividing the gas chamber in two.

In U.S. Pat. No. 4,657,713, a heater block of the humidifier incorporates a water supply and a semi-permeable filter membrane.

None of these prior art devices provide a satisfactory solution to the provision of humidified breathable gas to the patient, nor to the ease of construction, disposability, retrofitting and hygiene requirements for a humidification device.

SUMMARY OF THE INVENTION

One aspect of the present invention relates to a humidifier apparatus which overcomes or ameliorates disadvantages of the prior art.

In one embodiment, a humidifier apparatus comprises a housing which includes a gas inlet and outlet for the gas flow, a water supply distribution member that supplies water vapour to the gas flow and a heater apparatus that is in thermal contact with the water supply distribution member. The water supply distribution member has adaptations so that it is a removable and replaceable fitting to the humidifier apparatus.

In an embodiment, at least a part of the heater apparatus is also a removable and replaceable fitting to the humidifier apparatus

In a further embodiment, aspects of the humidifier apparatus may be disposable or the humidifier apparatus may provide one or more sub-components which may be removable for either replacement or re-use after servicing. For example, a thin, envelope form of the water supply distribution member may be disposable.

A further aspect of the invention provides that part of the heater apparatus forms part of the water distribution member. In an embodiment, this part of the heater apparatus may be an induction receiving element.

In an embodiment, the water supply distribution member may include a wick and/or capillary action device which provides water for vaporization into the gas flow.

A further aspect of the invention relates to a humidity control device which enables the amount of water vapour passing from the water distribution member to the gas flow to be controlled.

In an embodiment, the water supply distribution member may include a water filter.

In an embodiment, the gas flow path, the water distribution member and at least a part of the heater apparatus are located in the humidifier apparatus as a number of thin, adjacent layers. The thin layering of each of these components serves to improve the vaporization of the water and its mixing into the gas flow.

Another aspect of the invention relates to a humidifier apparatus for a respiratory apparatus including a housing providing a gas flow path, a heater apparatus, and a water supply distribution member configured and arranged to deliver water vapour to the gas flow path. The water distribution member is provided to the housing and in thermal communication with the heater apparatus.

Another aspect of the invention relates to a humidifier apparatus for a respiratory apparatus including a housing, one or more water supply distribution members removably fitted to the housing, and a heater apparatus in thermal communication with at least one of the water distribution members. The one or more water supply distribution members are configured and arranged to deliver water vapour to one or more gas flow paths defined by the one or more water supply distribution members and the housing.

Another aspect of the invention relates to a water distribution member for a humidifier apparatus including an envelope formed by a first compartment wall and a second compartment wall joined together, and a water inlet into the envelope.

Another aspect of the invention relates to a humidifier apparatus including a base plate removably and replaceably attachable to a humidifier housing, a heater apparatus provided to the base plate, and a water distribution member provided to the base plate. The water distribution member includes first and second compartment walls that define an envelope adapted to receive a supply of water. The first compartment wall includes a semi-permeable membrane adapted to allow water vapour to pass therethrough and the second compartment wall includes a thermally conductive wall in thermal communication with the heater apparatus.

Other aspects, features, and advantages of this invention will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, which are a part of this disclosure and which illustrate, by way of example, principles of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings facilitate an understanding of the various embodiments of this invention. In such drawings:

FIG. **1** is a schematic perspective view of a humidifier apparatus according to an embodiment of the present invention;

FIG. **2** is a cross-sectional view taken along the line **2-2** of FIG. **1**;

FIG. **3** is a cross-sectional view taken along the line **3-3** of FIG. **1**;

FIG. **4** is an enlarged view of the circled region **4** in FIG. **3**;

FIG. **5** is an exploded view of FIG. **3**;

FIG. **6** is a schematic perspective view of a water distribution member according to an embodiment of the present invention;

FIG. **7** is an exploded view of FIG. **6**;

FIG. **8** is a cross-sectional view across the line **8-8** of FIG. **6** of an alternate embodiment of a composite filter structure;

FIG. **9** is a schematic perspective view of a chassis for the water distribution member of FIG. **6** according to an embodiment of the present invention;

FIG. **10** is a cross-sectional view along the line **10-10** of FIG. **9**;

FIG. **11** is an alternate embodiment of the humidifier apparatus in FIG. **2**, where devices for humidity control are introduced according to an embodiment of the present invention;

FIG. **12** is an enlarged view of the circled region **12** in FIG. **11**;

FIG. **13** is an alternate embodiment, to that in FIG. **12**, for humidity control;

FIG. **14** schematically illustrates the partial shutter position for the humidity control embodiment of FIG. **13**;

FIG. **15** schematically illustrates the no humidification shutter position for the humidity control embodiment of FIG. **13**;

FIG. **16** is a cross-sectional view of a humidifier apparatus including another alternate embodiment for humidity control;

FIG. **17** is a cross-sectional view of a humidifier apparatus including yet another alternate embodiment for humidity control;

FIG. **18** is a partial, cross-sectional view of a further embodiment of FIG. **3** where an external water reservoir is introduced; and

FIG. **19** is a different, partial cross-sectional view of the embodiment of FIG. **18**.

DETAILED DESCRIPTION OF ILLUSTRATED EMBODIMENTS

The following description is provided in relation to several embodiments which may share common characteristics and features. It is to be understood that one or more features of any one embodiment may be combinable with one or more features of the other embodiments. In addition, any single feature or combination of features in any of the embodiments may constitute additional embodiments.

In this specification, the word "comprising" is to be understood in its "open" sense, that is, in the sense of "including", and thus not limited to its "closed" sense, that is the sense of "consisting only of". A corresponding meaning is to be attributed to the corresponding words "comprise", "comprised" and "comprises" where they appear.

The term "air" will be taken to include breathable gases, for example air with supplemental oxygen.

FIGS. **1** to **5** schematically show a first embodiment of a humidifier apparatus **110** for delivering water vapour into a breathable gas flow produced by a positive airway pressure device (or flow generator) of a respiratory apparatus such as a Continuous Positive Airway Pressure (CPAP) therapy machine.

With reference to FIG. **1**, the humidifier has a housing **112** which defines an upper internal gas flow path, described below with reference to FIG. **2**. The housing **112** includes a gas inlet **114**, which receives gas flow (indicated by an arrow) from the positive airway pressure device (not shown), a low-profile centre section **116** and gas outlet **118**.

In use, the gas outlet **118** of humidified breathable gas flow (indicated by an arrow) is typically connected to a patient conduit (not shown) which in turn is connected to the patient's mask. The form of the connectors for the gas inlet **114** and the gas outlet **118** may be of any suitable, conventional connector to enable connection to the positive airway pressure device and the patient conduit. The housing **112** also may have a water inlet passage **120** adapted for connection to a supply of liquid water for the humidifier apparatus. The water supplied is used for the humidification of the gas passing through the humidifier apparatus **110**.

The housing **112** of the humidifier apparatus **110**, as shown in FIG. **1**, may be of a material that is light, durable to heat and water and approved as safe for use in respiratory medical apparatus. In addition, the material may be sufficiently resilient to allow easy connection of the appropriate fittings to the gas inlet **114** and the gas outlet **118**. Preferable materials for the housing are resilient plastic like materials, for example polycarbonate, polycarbonate ABS blends or polypropylene. However, the housing may be constructed of other suitable materials.

In one embodiment, the housing **112** as shown in FIG. **1** may be generally rectangular in plan view with example dimensions of: approximate length **122** of 120 to 150 mm and a breadth **124** of 100 to 120 mm. The housing **112** may also have a downwardly extending peripheral flange **126** approximately 5 to 20 mm in height. The dimensions and shape of the housing **112** given here and later are given by way as examples for the embodiments described here. Other dimensions and shapes to those given may also be used, for example depending on the humidification capacity of the humidifier apparatus **110** and/or for compatibility with respiratory apparatus.

FIG. **2** is a cut away view taken along line **2-2** in FIG. **1**, showing the internal components and gas flow path **210** (indicated by the arrows), within the humidifier apparatus **110**.

The gas flow path **210** flows through the low profile centre section **116** of the housing **112** and over a water distribution member **211** that has a first compartment wall **212** which separates a liquid water layer **214** from the gas flow path **210**. The low profile centre section **116** of the housing **112** and the first compartment wall **212** form a gas passage layer **213** between the gas inlet **114** and gas outlet **118**. The gas flow **210** receives water vapour **216** through the first compartment wall **212** into the gas passage layer **213**, as indicated by arrows, so that ambient gas **210**A entering the humidifier apparatus **110** is humidified in the low profile centre section **116** and exits as humidified gas **210**B.

A second compartment wall **218**, which is also part of the water distribution member **211**, separates the water layer **214** from a heater apparatus **220**. The heater apparatus **220** is used to heat the water layer **214** to aid in the generation of water vapour **216** for the gas flow **210** (e.g., heater heats water layer to at least 100° C. to produce water vapour). A detailed description of the heater apparatus **220** is given below.

The function of the water distribution member **211** (including the first compartment wall **212**, the water layer **214**, and the second compartment wall **218**) is to distribute water to the gas passage layer **213**.

The humidifier apparatus **110** has a base plate **222** which fits into the housing **112**, by being received within a downwardly extending peripheral flange **126** of the housing **112**. When the base plate **222** is fully inserted into the base of the housing **112**, the base plate **222** abuts against the periphery of the second compartment wall **218** and against a shoulder **224** of the housing **112**. In this position, the base plate **222** provides support to the water layer **214** via the second compartment wall **218** and provides a gas seal to the gas flow path **210**. The base plate **222** also provides support to the heater apparatus **220**. A flexible ridge **226** which is part of or joins the flange **126** aids in securing the base plate **222** against the shoulder **224** of the housing **112**. In alternative embodiments, the securing function of the ridge **226** may replaced by conventional securing rings, pins, screws or other fastening devices for securing as commonly used by those skilled in the art.

The gas passage layer **213** may have by way of example breadth and length dimensions of about 50 to 150 mm respectively, e.g., about 100 by 100 mm. The thickness of the gas passage layer **213** above the first compartment wall **212** may be in the range of about 2 to 20 mm, e.g., about 5 to 15 mm (e.g., about 10 mm). The housing **112** with the first compartment wall **212** defines a gas volume in the humidifier apparatus **110** of about 50 to 500 ml, e.g., about 50 to 250 ml (e.g., about 80-150 ml). As described above, the dimensions and capacities given here and later are given by way as examples for the embodiments described. Other dimensions and capacities to those given may be used.

FIG. **3** is a cut away view taken along line **3-3** in FIG. **1**. FIG. **3** shows further internal components within the humidifier apparatus **110** and in particular the water distribution member **211**.

FIG. **4** is an enlarged view of the circled region **4** in FIG. **3**. As illustrated, liquid water to replenish the water layer **214** passes into the humidifier apparatus **110** via the water inlet passage **120** which increases in its transverse cross-section in order to distribute water across a filter **310** within the water distribution member **211**. In an embodiment, the lower section of the water inlet passage **120** is conical. The water inlet passage **120** volume above the filter **310** may also serve as a small reservoir of water for the water layer **214**. The filter **310** performs as a sterile filter to produce sterile water that may drain into the water layer **214** via a water inlet **312** that is within the water distribution member **211**. A filter to produce sterile water by removing bacterial and viral disease causing agents may also remove other agents, such as algae and fungal spores, which may lead to the growth of undesirable agents in the warm and moist environment within the humidifier apparatus **110**. In an alternate embodiment, the filter may remove particulates and/or dissolved ions from the liquid water to prevent fouling and blockages of the humidifier apparatus **110** in use. In a further embodiment, the filter **310** may be in the form of a plug which also occupies the conical space of the water inlet passage **120** that is above the first embodiment of the filter **310**. In another alternate embodiment, the filter **310** may be omitted from the water distribution member **211** and the water inlet passage **120** so that the water travels directly from the water inlet passage **120** to the water inlet **312**.

Further embodiments of the water distribution member **211** are described below with reference to FIGS. **6** to **9**.

Housing Embodiments

In FIGS. **1** and **2**, the gas inlet **114** and gas outlet **118** are located at either end of the length dimension **122** of the humidifier apparatus **110**. As illustrated, the gas inlet **114** is shown in a horizontal orientation and the gas outlet **118** is shown in a vertical orientation. However, the location and orientation of the gas inlet **114** and gas outlet **118** may be varied about the humidifier apparatus **110**. For example, in an alternate embodiment the gas inlet and outlet **114**, **118** may be attached at either end of the breadth dimension **124** of the humidifier apparatus **110**. Or, in another embodiment, the gas inlet and outlet **114**, **118** may be attached opposite each other with respect to the length dimension **122** or breadth dimension **124** but with a similar orientation to the horizontal/vertical. In an embodiment, the positioning of the gas inlet and outlets **114**, **118** is such that they may be opposed to each other across the gas passage layer **213** in order to maximise the amount of water vapour **216** taken up by the gas flow **210** across the water distribution member **211**. As an alternative, the gas inlet and outlets may be adjacent to one another with the gas passage layer extending along a tortuous path or a smaller path sufficient for humidification. Thus, any position for the gas inlet and outlets **114**, **118** serving this principle may be appropriate.

In yet another embodiment of the housing **112**, the generally rectangular plan view shape of the housing may be of any suitable shape. For example, the plan view shape of the housing may be circular or elliptical.

In the corresponding embodiments to the housing **112**, the gas passage layer **213**, with respect to FIGS. **2** to **5**, may be any suitable dimensions or shape to suit the housing **112** embodiments as described above. Similarly, the water distribution member **211** embodiments, with respect to FIGS. **2** to **10**, may have dimensions and shapes to suit the housing **112** embodiments as described above.

Removable and Replaceable Fittings

FIG. **5** is an exploded version of FIG. **3**. FIG. **5** schematically illustrates the various components of the humidifier apparatus **110** which can be readily disassembled and re-assembled. The base plate **222** may be separated entirely and then readily re-attached to the housing **112**. The base plate **222** is released from the housing **112** by bending back the flexible flange **126** so that the protruding edge of the ridge **226** no longer secures the periphery of the base plate **222** to the shoulder **224**. The base plate **222** may then be re-installed into the base of the housing **112** by a simple press fit to negotiate the base plate's **222** peripheral edge past the flexible ridge **226**.

When the base plate **222** is removed from the base of the housing **112**, the heater apparatus **220** which is seated in the base plate **222** may be removed and replaced or serviced. In addition, the water distribution member **211** may be removed from the housing **112** and replaced as a disposable item or serviced and replaced as described below.

In another embodiment, the heater apparatus **220** and base plate **222** are not separable from each other and form a single component.

When the components described above are removed from the housing **112**, the internal surfaces of the housing **112** may be readily accessed for inspection, cleaning or replacing as a disposable item. The water distribution member **211** may also be inspected, cleaned and sterilised or replaced as a low cost disposable item. The heater apparatus **220** and base plate **222** may be more durable and higher cost components which may be designed to be re-useable many times, although alternate embodiments are described below for the heater apparatus **220** and base plate **222** that are low cost and disposable.

The ability of the humidifier apparatus to be readily disassembled and re-assembled with replaceable components as described above is of a particular advantage for the on-going ease of maintenance of the humidifier apparatus **110** by a patient or their carer during the use of the respiratory apparatus.

The humidifier apparatus **110** may be readily used by different patients by attention to the components that are liable to contamination in use. For example, the housing **112** and the water distribution member **211** may be readily cleaned and sterilised or simply replaced as disposable items. The base plate **222** and heater apparatus **220** may not be contaminated because they are generally not in contact with the patient or the patient's airway with its associated secretions. Consequently, the base plate **222** and heater apparatus **220** may be re-used.

Water Distribution Member Embodiments

FIG. **6** is a perspective view of the water distribution member **211**. The plane surface of the first compartment wall **212** is shown uppermost with it extending to the shoulder **224** of the housing **112**. The first compartment wall by way of example may have breadth and length dimensions of about 50 to 150 mm respectively, e.g., about 100 by 100 mm. The overall dimensions and shape of the water distribution member **211** may correspond to that of the gas passage layer **213** and the housing **112** embodiments described above.

The first compartment wall **212** is preferably a semi-permeable membrane with the characteristic of preferentially allowing water vapour **216** to pass through it but impeding liquid water so that the gas passage layer receives water vapour **216** but no liquid water from the water layer **214**.

The semi-permeable membrane may be formed of a material which has fine pores or perforations and may also be hydrophobic, the fineness of the porosity or the perforations and/or the degree of hydrophobicity being adapted to result in the desired effect of semi-permeability for this application.

Some examples of semi-permeable membrane materials with suitable characteristics for use in the water distribution member according to an embodiment of the present invention include:

- Porous polytetrafluroethylene (PTFE) materials, microporous PTFE membranes and expanded PTFE (ePTFE) from Gore-tex® , W.L. Gore & Associates, Inc of Maryland USA.
- Tyvek® spun polyethylene sheet material from DuPont.
- PTFE mesh sold as Fluorcarbon SPECTRA/MESH® by Spectrum Laboratories of Rancho Dominguez, Calif. USA.
- Fibrous membranes consisting of auxetic fibres (fibres with a negative Poisson's Ratio).
- A more comprehensive discussion of suitable semi-permeable membrane materials is included in Patent Application No. WO 2006/069415 A1 "Respiratory Mask having Gas Washout Vent and Gas Washout Vent Assembly for Respiratory Mask", the contents of which are incorporated herein by reference.

In another embodiment, the surface of the first compartment wall **212** may have dimples or corrugations formed within it so as to increase the area of interaction with the gas flow path **210** and/or to promote the turbulent mixing of the water vapour **216** with the gas flow path **210**.

The first compartment wall **212** is joined to the second compartment wall **218** by a bonding strip **610** about the periphery of both compartment walls **212**, **218** to form a thin envelope containing the water layer **214**. The bonding strip **610** between the first and second compartment walls **212**, **218** may be achieved by heat sealing, an adhesive, welding or any suitable method of manufacture.

In FIG. **6**, the filter **310** is visible thru a filter aperture **612**. The filter **310** is sandwiched at its periphery by the first and second compartment walls **212**, **218** which in turn are bounded by the bond strip **610**. Liquid water flows through the filter aperture **612**, the filter **310** and into the water layer **214** (not shown in FIG. **6**) of the water distribution member **211**.

The second compartment wall **218** on the underside of the water distribution member **211** shown in FIG. **6** may be formed of materials of the type and form suitable to conduct heat from the heater apparatus **220** into the water layer **214**. Desirable properties of the second compartment wall **218** include that it may be thin so as to conduct and dissipate heat rapidly with very low thermal inertia and structurally robust and flexible so that it may readily conform to the surface of the heater apparatus **220**. Suitable materials for the second compartment wall **218** may be metallized plastic film, a metal foil such as aluminium or metal plastic composite. Further embodiments of the second compartment wall **218** in combination with the heater apparatus **220** are described below with the heater apparatus **220** description.

A thin envelope configuration as described above for the water distribution member **211** enables the water layer **214** within to be thin. In an embodiment, the thickness of the liquid water layer **214** by way of example may be about 1-5 mm, e.g., less than about 2 mm, however larger capacity versions may have a thickness up to and greater than 10 mm. The corresponding volume of the water layer **214**, by way of example, may range from less than 10 ml to larger capacity versions that may be up to and greater than 150 ml.

A thin water layer **214** of low volume may be heated rapidly with modest heating to produce adequate water vapour **216** for the humidification of the gas flow path **210**. Modest heating requirements enable a heating apparatus **220** of low power requirements to be used in the humidifier apparatus **110**.

In use, water vapour may also be produced within the envelope of the first and second compartment walls **212**, **218** as a result of heating from the heater apparatus **220**. In situations where a high humidification rate is required within the gas flow path **210**, the rate of heating by the heater apparatus **220** may be such that considerable amounts of water vapour are present with the liquid water within the water layer **214**.

An alternate embodiment of the water distribution member **211** may include the use of additional, partial bonding strips (not shown) across the plane of the first and second compartment walls **212**, **218** that partially join the compartment walls **212**, **218**. The additional, partial bonding strips may be arranged in such a manner to improve the rigidity of the water distribution member **211**, allow water to flow through the water layer **214** and to prevent ballooning where the envelope of the first and second compartment walls **212**, **218** may be inflated by the supply of water at an excessive pressure or vigorous heating by the heater apparatus **220** generating excessive water vapour. Ballooning of the envelope of the first and second compartment walls **212**, **218** may obstruct the gas passage layer **213**.

Filter Composite Structure

FIG. **7** is an exploded perspective view of the water distribution member **211** with an alternative embodiment of the filter **310** to that described with reference to FIG. **3** above. In this embodiment, the filter is in the form of a composite filter comprising a filter disc **710** and a filter support **712**. The filter disc **710** performs the filtering functions described above for the other embodiments. The filter disc **710** sits below the filter aperture **612** so as to receive all the water from the water inlet passage **120**. The filter disc **710** is supported by and sits within the filter support **712** in a manner that allows the water from the water inlet passage **120** to pass through the thickness of the filter disc **710** and freely drain from the lower side of the filter disc **710** to the water inlet **312**. To allow the free draining of the filter disc **710**, the filter support **712** consists of a very porous material which allows the filtered water to pass freely through it whilst providing structural support to the filter disc **710**. The filter support **712** material may be any one of many suitable porous materials such as foam plastics or foam form metals which are approved for medical respiratory apparatus use or alternatively a suitable plate with many through holes or a plate with many, small, raised protrusions on its surface. To aid in the free draining function of the filter support **712**, ribs **714** are located below the filter disc **710**. The ribs **714** form rib channels **716** which allow the filtered water to proceed freely to the water inlet **312** through the filter support **712** portion adjoining the water inlet **312**.

An advantage of the filter composite structure **710**, **712**, **714**, **716** described above is that the expensive filtering material is limited to a filter disc **710** to coincide with the filter aperture **612** rather than occupying the rest of the filter volume in which the filter support **712** resides.

FIG. **8** is a cross-sectional view across the line **8-8** of FIG. **6** of an alternate embodiment of a composite filter structure. In this embodiment, multiple filter walls **810** are used to support a filter infill **812** where the filter infill **812** performs the filtering functions described above for the other filter embodiments. The top of the filter infill **812** corresponds to the filter aperture **612** for receiving the water for filtering. Along the bottom of each of the multiple filter walls **810** are a number of filter wall apertures **814** that allow the filtered water to move from and through a number of bottom channels **816** (which are below the filter infill **812**) to the water inlet **312** of the water layer **214**. In use, the water flow **818** is indicated by the dashed lines with arrows. For this embodiment, there may be multiple water inlets **312** depending on the number of filter wall apertures **814** in the filter wall **810** adjoining the water layer **214**.

In an alternative embodiment to those described above, the filter **310**, **710**, **712**, **714**, **716**, **810**, **812** may be omitted and/or optional. In this embodiment, the liquid water may pass freely through the filter aperture **612**, through the water inlet **312** and into the water layer **214** as bounded by the first and second compartment walls **212**, **218**.

Chassis for Water Distribution Member

The single structure form of the water distribution member **211** facilitates it being readily removable from the humidifier apparatus **110** and being replaceable as described above with reference to FIG. **5** and below with reference to FIGS. **9** and **10**.

FIG. **9** is a perspective view of a chassis **910** that may be used as a further embodiment for the support of the water distribution member **211** according to any one of the water distribution member **211** embodiments described above. The chassis **910** may be made of a material which is rigid, such as plastic or a metal frame. To improve the rigidity of the chassis **910**, braces **912** may be incorporated in the underside of the chassis **910**. The braces **912** are shown in dashed outline on FIG. **9** in order to represent their location under the water distribution member **211**. The braces **912** are of a thin profile and of an appropriate material for contact with the heater apparatus **220**.

The chassis **910** may have a protruding tab **914** that facilitates the insertion and removal of the chassis **910** and water distribution member **211** to the humidifier apparatus in the direction shown by the bi-directional arrow **916**. The arrangement (not shown) for accommodating the chassis **910** into the humidifier apparatus **110** may comprise of increasing the downward length of the flange **126** and increasing the distance between the shoulder **224** of the housing **112** and the periphery of the base plate **222** in order to allow the chassis to slid in and out of a space between the shoulder **224** and the base plate **222**. In order for the chassis **910** to access this space, the flange **126** along the length dimension **122** may be omitted. In addition, the profile of the chassis **910** may be adapted so that as it slides into the humidifier apparatus **110** the periphery of the water distribution member **211** is caused to make a gas tight seal with the shoulder **224** of the housing **112**. Similarly, the second compartment wall **218** of the water distribution member **211** is caused to be in thermal contact with the heater apparatus **220**.

The chassis **910** may be secured in position within the humidifier apparatus **110** by any one of many mechanical options available to a person skilled in the art.

FIG. **10** is a cross-sectional view along the line **10-10** of FIG. **9**. FIG. **10** illustrates how the water distribution member **211** is contained within the chassis **910**. The water distribution member **211** may simply rest within the chassis **910**.

The advantage of an alternate embodiment including a chassis **910** is that a simple single step sliding action to replace the water distribution member **211** may be done rather than a more involved action of the removal of the base plate **222** and the heater apparatus **220** as described in other embodiments above.

In another embodiment, the humidifier may have a hinged upper section to allow access to the water distribution member for easy insertion and replacement.

Wick Embodiment

An alternative embodiment for the water distribution member **211** is the use of a wick and/or capillary action device (not shown) in place of the first compartment wall **212** and the water layer **214**. The wick device has the ability to conduct water upon or within the wick device such that water is available for vaporisation into the gas passage layer **213**. In addition, a capillary action may also be involved within the wick device. An example of a suitable wick device is a material which is hydrophilic so that the water has a tendency to spread across the extent of the material. Materials that may be suitable include cotton, activated perfluorinated polymer (e.g., "NAFION" stabilised perfluorosulfonic acid/PTFE copolymer by DuPont), polyester copolymer (e.g. SYMPATEX polyester/polyether copolymer by Sympatex Technologies GmbH of Germany) and polyester fabrics (e.g., COOLMAX polyester fabrics by Invista of USA). Alternatively, a material may be imparted hydrophilic characteristics by using a particular liquid film or the application of a gel or solid film.

The wick device may have an internal structural form of a fabric, sponge, a film, a bundle of fibres or a hydrophilic porous, flexible solid, e.g., plastic, metal or ceramic. The external form of the wick device may be of a continuous liner upon the second compartment wall **218**. In an alternate embodiment of the external form, the wick device liner may be in the form of a corrugated or dimpled liner upon the second compartment wall **218** so that the area of interaction between the gas flow path **210** and the wick device is increased.

Alternatively, the wick device may be in the form of a very gas porous membrane that may extend partially or wholly across the transverse cross section of the gas passage layer **213**, the material forming the membrane being as per that described above for the wick.

In another embodiment of the wick device, the second compartment wall **218** may be omitted and the wick device as a continuous sheet may be joined to a peripheral frame in place of the bond strip **610** described in the above embodiments. In a further embodiment, a grid support structure may be located with the continuous sheet of the wick device and also be joined to the peripheral frame.

The water supply for the wick device may be in the forms described above for the other embodiments of the water distribution member **211**.

In a further hybrid embodiment of the water distribution member **211**, the wick device may reside within the envelope formed by the compartment walls **212**, **218**, as described above for the other embodiments.

Heater

For all the above described embodiments of the water distribution member **211**, a heater apparatus **220** may be used to increase the amount of water vapour **216** produced by the water distribution member **211**. The heater apparatus **220** may consist of a heating element (not shown) embedded within or attached to a metal or ceramic block which is against the second compartment wall **218**. The heating element may for example consist of a resistive conductor. The conductor may consist of multiple resistive conductors connected to each other in series, parallel or segmented about the heater apparatus **220** in order to allow uniform, variable and/or sectional heating of the second compartment wall **218** and through it the water layer **214**.

The base plate **222**, as well as providing support as described above, insulates the heater apparatus from any surface that the humidifier apparatus **110** may rest upon. The base plate **222** may be made of a material or a composite of materials which provide suitable refractory properties for the temperature range of the heater apparatus **220** and suitable insulation properties. A person skilled in the art of manufacture may select from any one of many widely available materials suitable for the purpose, for example a ceramic composite or a variety of high temperature plastics.

In addition, the base plate **222** may have electrical connections (not shown) to which the heating element of the heater apparatus **220** may connect with in a manner that allows the base plate **222** to be readily disassembled and re-assembled to the heater apparatus **220** as described above with reference to FIG. **5**. The external surface of the base plate **222** may have corresponding electrical connections (not shown) so that the heating element may receive its electrical power supply from the respiratory apparatus that the humidifier apparatus **220** may be connected with or alternatively the heating apparatus may have its own power supply. The form and materials that may be used for the electrical connections may be any suitable one of the many options available to a person skilled in the art. For example, the metal electrical contacts may be of a male-female engagement arrangement or a simple, flat sliding contact.

In an alternative embodiment, the heater apparatus **220** may be located within a section of the respiratory apparatus that the humidifier apparatus **110** sits upon. The heater apparatus **220** may have a heater plate (not shown) which may be in thermal contact with the base plate **222** when the humidifier apparatus **110** rests upon the respiratory apparatus. The base plate **222** in this embodiment is of a suitably thermally conductive material, such as a metal, which is also in thermal contact with the second compartment wall **218**.

In a further embodiment, the base plate **222** and the second compartment wall **218** may be combined in a single structure to form a heater plate that may comprise of thin metallised foil in the portion adjacent to the water layer **214**. A peripheral support rim for the heater plate **218**, **222** may be used to secure the water distribution member **211** against the shoulder **224** with the ridge **226**.

Filament or Strip Heater

In another embodiment, the heater apparatus **220** may be in the form of a filament or tape heater element which may be attached to the side of the base plate **222** which is adjacent to the second compartment wall **218**. In an alternative embodiment, the filament or tape heater element may be attached to or incorporated within the second compartment wall **218**. In yet another embodiment, the filament or tape heater element may be located within the water layer **214** or in the wick device embodiment of the water distribution member **211** the heater element may be interwoven with or adjacent to the wick device as described above. The necessary electrical connections to the electrical power supply are as described above.

The filament heater element may be in the form of a conventional resistive wire heater. The tape heater element may be a flexible tape heater as described in Australian

Patent Application No. 2006906224 "Humidifier for a Respiratory Apparatus", the contents of which are incorporated herein by reference. In one embodiment of the flexible tape heater, the heating element may be formed by printed circuit techniques applied to a surface of a flexible substrate such as silicone rubber, all-polyimide or PTFE. Included in the printed circuit techniques which may be used are etched foil, printing and vacuum deposition techniques. The Thermofoil™ range of the type of flexible heaters by Minco of Minneapolis USA, described at www.minco.com, are examples of commercially available strip heaters which may be modified for use in the present application. Alternatively, the flexible tape heater may be formed as a heating element, for example in the form of a resistive wire or ribbon, laminated between tapes of polycarbonate or other suitable plastics film.

Induction Heater

An alternate embodiment of the heater apparatus **220** may comprise of an induction heating system. In such a system, a transmitting induction coil is used to generate electromagnetic radiation which may be transmitted without the requirement for an electrical, magnetic or mechanical connection to an induction receiving element. The electromagnetic radiation induces eddy currents within the induction receiving element which may then heat the heater element by electrical resistance heating (Joule effect). In an alternate embodiment, a design of the induction heating system may use magnetic hysteresis losses for heating in the induction receiving element with or instead of eddy current resistive heating.

Induction heating systems may be designed and fabricated by a person skilled in the art of induction heating systems as well as by reference to novel induction heaters such as in Patent Application No. PCT/AU2007/000274 "Induction Heating System and Method for Humidifier", the contents of which are incorporated herein by reference.

For the humidifier apparatus **110**, the transmitting induction coil (not shown) together with the associated power supply and control system may be located with the respiratory apparatus. The humidifier apparatus **220** may be located in the vicinity of the induction coil, sufficiently close that the induction receiving element (not shown) within the humidifier apparatus **220** receives sufficient electromagnetic radiation from the induction coil to induce heating. The induction receiving element may be located between the base plate **222** and the second compartment wall **218** such that it is in thermal communication with the second compartment wall **218**. The base plate **222** may be made of materials or of structure to which induction by electromagnetic radiation does not significantly occur. For example, a non-conducting ceramic, plastic or a lamination arrangement of metal and an insulator/dielectric.

In an alternative embodiment, the second compartment wall **218** forms an induction receiving element. The second compartment wall **218** may comprise in part at least of a metal foil that is sufficiently conducting to have eddy currents induced within it and/or sufficiently magnetisable to undergo magnetic hysteresis under the applied electromagnetic radiation. In a further embodiment, the base plate **222** may be omitted.

An induction heating system offers the advantage that the induction receiving element may have a very low thermal inertia such that it may be heated to in excess of 100 degrees Celsius within a short time, for example less than 2 minutes to enable the rapid generation of water vapour **216**. Similarly, the low thermal inertia of the induction receiving element enables a rapid cooling down, particularly when the water layer **214** thickness is thin. In addition, for the embodiment where a low cost induction receiving element is incorporated in the second compartment wall **218**, the disposability of the water distribution member **211** is improved.

Cooling and Heating by the Heater Apparatus

In a further embodiment to the heater apparatus **220** embodiments described above, the heater apparatus **220** may be a Peltier thermo-electric element that may be used to cool or heat. The Peltier thermo-electric element may be present within the humidifier apparatus **110** or external to it as per the embodiments described above. Electrical supply and control of the Peltier thermo-electric element to heat or cool may be by the respiratory apparatus or a separate electrical supply and control unit.

The Peltier thermo-electric element may be used to cool the water layer **214** to well below the ambient temperature so that the generation of water vapour **216** is minimal and consequently there is minimal humidification of the gas passage layer **213** and the gas flow **210**B from the humidifier apparatus **110**. Conversely, the Peltier thermo-electric element may be used to variably heat the water layer **214** to produce the desired amount of water vapour **216** to humidify the gas flow **210**B from the humidifier apparatus **110**

Sterilisation

In a further embodiment, in-situ high temperature sterilisation may be used with the heater apparatus' **220** capacity to rapidly heat to a temperature in excess of 100 degrees Celsius for a predetermined period of time. The low thermal inertia of the humidifier apparatus **110** allows for its rapid cool down and subsequent use for humidification. Such a sterilising technique offers a convenient method to counteract the lodgement and growth of disease causing agents within the humidifier apparatus **110**. An alternative sterilisation method may be by the use of a chemical treatment to one or more surfaces or materials within the humidifier apparatus **110**, for example the water distribution member **211** may be permanently impregnated with a chemical that inactivates viruses and arrests bacterial growth.

Humidity Control

FIG. **11** is a further embodiment of that in FIG. **2** where structures are introduced to enable the amount of humidification of the gas flow path **210** to be controlled. The gas passage layer **213** is vertically split by a plate **1110** into two further passage layers, each for a stream of the divided gas flow path **210**A. The humidification gas stream **210**C travels in the lower passage layer **1112** along the first compartment wall **212** and may receive water vapour **216** being issued from the first compartment wall **212**. The other stream is the dry gas stream **210**D which travels along the upper passage layer **1114** and is not humidified. The humidified and dry gas streams are recombined at the exit end of the upper and lower passage layers **1112** and **1114** to form the humidified gas flow **210**B which flows out of the humidifier apparatus **110** via the gas outlet **118**.

At either end of the upper passage layer **1114** are a pair of miniature upper butterfly valves **1116** which can be used to vary the amount of gas flow **210**A entering into the upper passage layer **1114**. In FIG. **11** the upper butterfly valves are shown in the open position to allow gas flow **210**A to pass freely through as gas flow **210**D. The lower passage layer **1112** at either end also has a pair of miniature lower butterfly valves **1118**, which in FIG. **11** are shown in the closed position.

FIG. **12** is an enlarged view of the dash encircled region **12** in FIG. **11**. FIG. **12** illustrates the functioning of the upper and lower butterfly valves **1116**, **1118**. In this valve configuration, there is no gas flow through lower passage layer **1112** and so no humidification of the gas flow **210** may occur. Only dry gas flow stream **210**D may occur. If the pair of lower butterfly valves **1118** are opened fractionally then there will be a humidified gas stream **210**C combining with the dry gas stream **210**D to form the humidified gas flow **210**B. Controlling the relative positions of the upper and lower butterfly valves **1116**, **1118** enables the level of humidity in the gas flow path **210**B to be varied.

The upper and lower butterfly valves **1116**, **1118** may be actuated by any suitable electrical and/or mechanical systems (not shown) available to a person skilled in the art of miniature motion systems. The actuation method may be controlled by a controlling unit (not shown) either located with the respiratory apparatus or as a separate controlling unit. The controlling unit may in turn be controlled by a humidity sensor or humidity controller.

FIG. **13** is an alternative embodiment to the above butterfly valves, where a sliding shutter **1310** with an aperture **1312** is used to control the relative amounts of the humidified and dry gas streams **210**C, **210**D. The shutter **1310** position shown in FIG. **13** is obstructing the upper passage layer **1114** at its exit end so that gas flow **210** is preferentially via the lower passage layer **210**C. Thus, the ambient gas flow **210**A is humidified by its passage through the lower passage layer **210**C.

FIG. **14** shows the shutter **1310** when it has been slid partially downwards in the direction of the arrow. In this position, the aperture **1312** partially obstructs the upper passage layer **1114** such that there is a partial dry gas flow stream **210**D. Correspondingly, the lower end of the shutter partially obstructs the lower passage layer **1112** so that there is also a partial humidified gas flow stream **210**C. In such a manner, the movement of the sliding shutter can be used to vary the humidity of the humidified gas flow **210**B.

FIG. **15** illustrates the end portion of the sliding shutter **1310** fully obstructing the lower passage layer **1112** whilst the aperture **1312** allows the dry gas stream **210**D to flow freely through the upper passage layer **1114**. In this shutter **1310** position, there is no additional humidification of the gas flow **210**A.

The actuation of the sliding shutter **1310** may be by any suitable electrical and/or mechanical systems (not shown) that are readily available to a person skilled in the art of miniature motion systems. The controlling (not shown) of the sliding shutter **1310** position may be in the same manner as described for the butterfly valve embodiment above.

FIG. **16** shows an alternate embodiment to the use of the butterfly valves or sliding shutter for humidity control. In FIG. **16**, the plate **1110** is attached to a shaft **1610**. The central section of the plate **1110**, where the shaft **1610** is attached, is flexible such that if the shaft is moved downwards as indicated by the arrow the lower surface of the plate **1110** may obstruct the lower passage layer **1112** thereby preventing the humidified gas flow stream **210**C whilst allowing the dry gas stream **210**D to flow. A threaded thumb wheel **1612** may be wound manually to move the shaft **1610** appropriately.

If the shaft **1610** is moved upwards, using the thumb wheel **1612**, as indicated by the arrow the upper passage layer **1114** may be obstructed thereby preventing the dry gas stream flow **210**D whilst allowing the humidified gas flow stream **210**C. The vertical position of the shaft **1610** may thus be used to control the level of humidity of the humidified gas flow **210**B.

The actuation of the shaft **1610** may be by any suitable electrical and/or mechanical systems that are readily available to a person skilled in the art of miniature motion systems. The controlling (not shown) of the shaft **1610** vertical position may be in the same manner as described for the butterfly valve and sliding valve embodiments above.

Overlapping Blade Arrangement

FIG. **17** schematically shows yet another alternative embodiment for humidity control. The overlapping blade arrangement comprises of a variable aperture **1710** formed by two overlapping blades, a stationary blade **1712** and a moving blade **1714**. The variable aperture controls the amount of interaction between the source of water vapour **216**, the first compartment wall **212**, and the gas flow path **210** in the gas passage layer **213**. FIG. **17** illustrates the fully open aperture state where the moving blade **1714** is fully retracted into the underside recess **1716** of the stationary blade **1712**. In the fully open aperture state, all of the water vapour **216** which may issue from the first compartment wall **212** is available for mixing into the gas flow **210** in the gas passage layer **213**.

In the fully closed aperture state, the moving blade **1714** would extend from the underside recess **1716** until moving blade **1714** completely covers the variable aperture **1710**. In such a fully closed aperture state, there is no transfer of water vapour **216** into the gas flow **210** in the gas passage layer **213**, thus no humidification of the gas flow **210** occurs in the humidifier apparatus **110**. In between the fully closed and fully open aperture states any number of humidification rates may be obtained by adjusting the position of the moving blade **1714**. In the embodiment of FIG. **17**, three sets of blades **1712**, **1714** with corresponding variable apertures **1710** are shown. Each set of blades may be operated independently or in a synchronised fashion with the other blade sets. The operation of the blades may be by a mechanical device controlled manually or an electro-mechanical device with a computer or analogue circuit servo controller that operates in response to a humidity and/or temperature sensor or any suitable miniature actuation system available to a person skilled in the art.

In further alternative embodiments to the above overlapping blade arrangement, a variable level of exposure of the first compartment wall **212** to the gas flow **210** in the gas passage layer **213** may be achieved by:

- A retractable full width blade across the first compartment wall **212**.
- Two sets of co-axial and overlapping radial blades adjacent to the first compartment wall **212**. The radial blade arrangement operates by rotating one or both blade sets in opposite directions so as to open or reduce the radial apertures formed between the radial blades.
- A variable aperture may be formed by use of an iris diaphragm.

Heater Apparatus and Humidity Control

In a further alternate embodiment for the humidity control, the heater apparatus **220** embodiments as described above may be used with or without the use of the other humidity control embodiments described above.

Water Reservoir

The water supply may comprise a temporary connection of a single filling, as described with reference to FIG. **3** above, at the start of an overnight therapy session of CPAP for OSA.

FIG. **18** is a partial, cross-sectional view of a further embodiment of FIG. **3** where an external water reservoir **1810** rests upon the low profile centre section **116** of the housing **112**. The external water reservoir **1810** has a drain **1812** which mates with the water inlet passage **120** so that water **1814** may be supplied as a gravity feed to the humidifier apparatus **110**. The external water reservoir **1810** may have a capacity of 200 to 1000 ml or may be any desired volume depending on the application and the desired humidification capacity of the humidification apparatus.

In an alternative embodiment, the external water reservoir **1810** may be located elsewhere, such as with other components of the respiratory apparatus. A micro-pump may then be used to supply the water to the water inlet passage **120**.

FIG. **19** is a different, partial cross-sectional view of the embodiment of FIG. **18**. The cross-section taken is as per that for FIG. **2** above. FIG. **19** schematically illustrates a fastening device to secure the water reservoir **1810** to the housing **112**. Two or more flexible latches **1910** are used to engage a rim **1912** of the external water reservoir **1810**, e.g., snap-fit attachment. The flexibility of the latches **1910** is such that they may be manually pried apart to disengage from the rim **1912** of the water reservoir **1810**. Refitting the external water reservoir **1810** may be done by using the snap-clip feature of the latches **1910** as the external water reservoir **1810** is pushed onto the housing **112** at the low profile centre section **116**. In an embodiment, the flexible latch may be provided about the entire perimeter.

Application to Existing Respiratory Apparatus

In a further embodiment, the humidifier apparatus may have adaptations which enable it to be accommodated into existing, conventional respiratory apparatus in order to improve the performance of the respiratory apparatus. The overall shape of the humidifier apparatus **110** may be varied in order for it to attach with an existing respiratory apparatus. The base plate **222** may be configured appropriately to make the required thermal and/or electrical contact with the respiratory apparatus. The gas inlet and outlet **114**, **118** may be configured to make an appropriate gas seal with the corresponding gas fixtures of the existing respiratory apparatus.

Additional Advantages

The humidifier apparatus **220** with the thin gas passage layer **213** upon a planar water distribution member **211** offers the advantage of having a very high surface area of interaction between the gas flow **210** and the source of water vapour **216**. The comparatively small volume of liquid water **214** within the water distribution member **211** compared with conventional tub humidifiers gives an additional advantage of a humidifier apparatus **110** with a very low thermal inertia. Such a system may have a rapid thermal response for the production and cessation of water vapour **216** for the humidification of the gas flow **210**.

The use of an envelope about the water layer **214** by the water distribution member **211** reduces the problem of tilting and consequential spillage of water that a conventional tub humidifier is prone to.

While the invention has been described in connection with what are presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the invention. Also, the various embodiments described above may be implemented in conjunction with other embodiments, e.g., aspects of one embodiment may be combined with aspects of another embodiment to realize yet other embodiments. Further, each independent feature or component of any given assembly may constitute an additional embodiment. Furthermore, each individual component of any given assembly, one or more portions of an individual component of any given assembly, and various combinations of components from one or more embodiments may include one or more ornamental design features. In addition, while the invention has particular application to patients who suffer from OSA, it is to be appreciated that patients who suffer from other illnesses (e.g., congestive heart failure, diabetes, morbid obesity, stroke, bariatric surgery, etc.) can derive benefit from the above teachings. Moreover, the above teachings have applicability with patients and non-patients alike in non-medical applications.

What is claimed is:

1. A respiratory treatment apparatus comprising:

a positive airway pressure device to provide a source of flow of air at positive to ambient;

a humidifier housing having a gas inlet to receive sealably the flow of air at positive pressure from said source in use and a gas outlet adapted to be connected to a gas conduit to deliver humidifier gas to a patient mask;

a plate positioned within the humidifier housing;

a water distribution member forming a water envelope for receiving liquid water, the water distribution member being fitted into the humidifier housing and including an upper wall and a lower wall between which the water envelope is formed, the upper wall being a semi-permeable material positioned below but spaced from the plate, and the lower wall being a heat conductive material;

an electric heater in thermal contact with the lower wall and adapted to heat the liquid water to form water vapor;

a gas passage layer between the gas inlet and the gas outlet, the gas passage layer configured to permit a gas flow to flow from the gas inlet to the gas outlet, the water distribution member being configured and arranged to deliver water vapor to the gas passage layer;

wherein:

the plate splits the gas passage layer into a humidification passage and a dry gas passage, the humidification passage being positioned between the upper wall of the water distribution member and the plate, the dry gas passage being positioned between the plate and a wall of the humidifier housing above the plate,

an amount of the gas flow entering into the humidification passage and the dry gas passage is variable, and

the semi-permeable upper wall of the water distribution member is configured to deliver the water vapor but not the liquid water to the humidification passage; and

the water distribution member has a flange that is sandwiched between the humidifier housing and a base plate connected to the humidifier housing.

2. The respiratory treatment apparatus according to claim **1**, wherein the plate is configured to direct a portion of gas from the gas flow away from the humidification passage and into the dry gas passage.

3. The respiratory treatment apparatus according to claim **1**, wherein the humidification passage includes a valve for varying the gas flow through the humidification passage and wherein the dry gas passage includes a valve for varying the gas flow through the dry gas passage.

4. The respiratory treatment apparatus according to claim **1**, wherein during use the gas flow is configured to be split between the humidification passage and the dry gas passage such that a humidification flow added to a dry gas flow equals the gas flow, wherein reducing the humidification flow increases the dry gas flow and increasing the humidification flow decreases the dry gas flow, wherein the gas flow enters the gas passage layer at a first humidity and exits the gas passage layer at a second higher humidity.

5. The respiratory treatment apparatus according to claim 1, wherein the dry gas passage includes a dry gas flow regulator and the humidification passage includes a humidification flow regulator, wherein the dry gas flow regulator and the humidification flow regulator are variable to vary a humidity level the gas flow at the gas outlet.

6. The respiratory treatment apparatus to claim 5, wherein the dry gas flow regulator is a butterfly valve and the humidification flow regulator is a separate butterfly valve.

7. The respiratory treatment apparatus according to claim 1, further comprising a sliding shutter, the sliding shutter including an aperture and a blocker, the sliding shutter being movable, wherein during use when the blocker blocks the gas flow through the dry gas passage, gas is directed to the humidification passage, and wherein when the aperture is aligned with the dry gas passage, gas is permitted to flow through the dry gas passage.

8. The respiratory treatment apparatus according to claim 1, wherein the semi-permeable upper wall of the water distribution member forms a portion of the humidification passage and the humidifier housing forms a separate portion of the dry gas passage.

9. The respiratory treatment apparatus according to claim 1, wherein the humidifier housing is detachable from the positive airway pressure device.

10. The respiratory treatment apparatus according to claim 1, wherein the water distribution member has a thickness of about 1-10 mm.

11. The respiratory treatment apparatus according to claim 1, wherein the water distribution member has a thickness of less than about 2 mm.

12. The respiratory treatment apparatus according to claim 1, wherein the water distribution member and the heater are removably attached to the humidifier housing.

13. The respiratory treatment apparatus according to claim 12, wherein the base plate supports the heater, and wherein the base plate, the water distribution member and the heater are removably attached to the humidifier housing.

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